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THE PLANT DISEASE REPORTER

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PLANT DISEASE EPIDEMICS
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IDENTIFICATION SECTION

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The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Plant Disease Epidemics and Identification Section serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

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PLANT DISEASE EPIDEMICS AND IDENTIFICATION SECTION

Horticultural Crops Research Branch — Plant Industry Station, Beltsville, Maryland
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CAPTAN AND ZINEB, USED ALONE, IN ALTERNATION, AND IN COMBINATION -- AND THE CONTROL OF APPLE DISEASES[1]

J. W. Heuberger, W. R. Comegys, and R. R. Romanko[2]

ABSTRACT

Research on captan and zineb for the control of apple diseases has shown that captan possesses certain advantages over zineb, particularly for scab control and fruit finish; contrariwise, zineb possesses certain advantages over captan, particularly for sooty blotch, rust and, possibly, fire blight control. Neither material used alone was completely satisfactory as an all-season spray. A combination of captan and zineb (half-strength of each) gave control of all the diseases present, was non-injurious, produced fruit having the highest finish, and resulted in residues well under the established tolerances for both captan and zineb. The alternating schedule of captan and zineb was equal to the combination of the two, except possibly for fruit finish.

INTRODUCTION

In 1947, the Department of Plant Pathology, Delaware Agricultural Experiment Station, began a long-range research program on the development and evaluation of organic fungicides for the control of apple and peach diseases. This investigation has entailed intensive and extensive screening tests of the chemicals in the field, as well as laboratory screening for fungicidal activity against the causal organisms. During the period 1947-1951, inclusive, 16 organic chemicals were tested. Of these, captan[3] and zineb[4] showed the most promise for control of several diseases and were the least phytotoxic; maneb[5] also showed good disease control.

Beginning in 1952, research was concentrated on the use of captan, zineb and maneb on apples. Results obtained that year on the Rome variety (4)[6] showed that captan was more effective than zineb and maneb for control of scab (Venturia inaequalis) but much less effective for control of the apple cedar rust (Gymnosporangium juniperi-virginianae). On the Starr variety, it was found that zineb gave control of fire blight (Erwinia amylovora) and frog-eye or black rot leaf spot (Physalospora obtusa) (5, 13); captan was not used in this test. The data on fire blight control by zineb support those obtained by Thomas and Henderson (16) under Colorado conditions.

From the local results obtained in 1952 showing that captan was more effective than zineb for scab control but less effective for apple cedar rust control and that zineb gave excellent control of frog-eye leafspot and good control of apple fire blight, together with the results of Groves (2,3) in Virginia showing that captan failed to control sooty blotch (Gloeodes pomigena), and those of Palmiter (10, 11, 12) in the Hudson River Valley showing that zineb and nabam[7] were effective for the control of sooty blotch as well as apple cedar rust, it was apparent that these two fungicides (captan, zineb) had a pronounced differential action in the control of several apple diseases. Although not enough data were available, there was some evidence that captan controlled those diseases that zineb did not control, whereas zineb controlled those that captan did not.

In view of this evidence, it was decided that future research, beginning in 1953, would deal with a study of the relative effectiveness of captan and zineb for the control of apple diseases when used alone, in alternation, and in combination. The results of such a study, provided worthwhile control data were obtained, would supply much needed information on the following

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[1] Published as Miscellaneous Paper No. 244 with the approval of the Director of the Delaware Agricultural Experiment Station. Contribution No. 84 of the Department of Plant Pathology.

[2] Research Professor, formerly Assistant Research Professor, and formerly Graduate Research Assistant, respectively.

[3] captan = N-(trichloromyehylthio)-4-cyclohexene-1, 2-dicarboximide.

[4] zineb = zinc ethylenebis [dithiocarbamate].

[5] maneb = manganous ethylenebis [dithiocarbamate].

[6] Refers to Literature Cited.

[7] nabam = disodium ethylenebis [dithiocarbamate].

Table 1. Control of fire-blight, frog-eye leafspot and scab diseases on apples, Starr variety, Bridgeville, 1953.

Treatment[a,b,c]	Concentration[d] (lbs.-gals.)	Fire-blight (Index)[e] 1953	1952	Frog-eye (Index)[f] 1953	1952	Scab[g] %
*Untreated	--------	1.25	3.1	2.25	6.2	21
*Dithane Z-78	2-100	1.00	1.5	0.75	1.7	1
ditto	2-100	0.50		0.25		0
ditto	1-100	1.25		1.00		2
*Parzate	2-100	1.50	0.7	0.00	1.4	1
*Manzate	1½-100	0.75	1.3	0.25	2.5	1
Fermate	2-100	1.00		0.25		1
Captan	2-100	0.25		0.25		0
Captan + Dithane Z-78	1-1-100	0.25		0.25		0
Mag. 70 Sulfur + Dithane Z-78	4-1-100	1.00		0.75		1
*Thiolutin	30 ppm	0.00	1.7	1.50	5.6	8
Thiolutin + Mag. 70 (4 lbs.)	30-4800 ppm	1.00		2.25		4
Thiolutin + Dithane Z-78 (1 lb.)	30-1200 ppm	0.00	2.4	1.25		9
*Terramycin	120 ppm	0.25		1.00	5.5	20
*Streptomycin sulfate	30 ppm	0.75	1.4	2.00	6.1	14
ditto	15 ppm	0.50		2.50		18
L.S.D. @ 5% P		N.S.	1.6	1.17	1.5	8
L.S.D. @ 1% P		N.S.	2.2	1.55	2.0	11

* Treatments and trees same as in 1952.

[a] Delayed Dormant Application: Bordeaux (2-2-100) and Superior Oil (2%).

[b] Test Materials Applied: Early Pre-Pink (Mar. 28); Pink (Apr. 7); Full Pink (Apr. 14); Full Bloom (Apr. 20); Petal Fall (Apr. 28); 1st Cover (May 7); 2nd Cover (May 18); 3rd Cover (June 5).

[c] Insecticides Added: Lead arsenate (3-100) and EPN (3/4-100) at Petal Fall and 1st Cover. DDT (2-100) at 2nd and 3rd Covers.

[d] 30 ppm = 0.024 pounds to 100 gallons of water.

[e] Fire blight was first found on May 18. The data listed are for the June 12 scoring.

[f] Frog-eye was first observed on April 14 on the basal leaves. The data listed are for the June 12 scoring.

[g] Data are harvest scores, July 2, using 250 fruit for each of four trees.

NOTE: The 1952 data on fire blight and frog-eye control are listed for purposes of comparison.

points: (a) what diseases were controlled by which fungicide; (b) when should each be used (in alternation) to provide control of a range of diseases; and, (c) would a combination treatment (half-strength of each) give control of those diseases which one or the other of the two fungicides failed to control?

During the course of research for the period 1953-1955, inclusive, data were also taken in all tests on phytotoxicity, compatibility with insecticides, and fruit finish.

While this work was in progress, several preliminary reports were published (6, 7, 8, 9, 14). It is the purpose of this paper to present complete information for the 3-year period, 1953-1955, inclusive.

EXPERIMENTATION AND RESULTS

1953 Tests

Four experiments were conducted, two at the University Farm, Newark, and two at Bridgeville.

Starr Variety, Bridgeville (fire blight, frog-eye leafspot, and scab): The objective of this experiment was to evaluate various fungicides and antibiotics for disease control. The block was the same as that used in 1952. Each material was applied to four single-tree plots. Spraying was done with a hydraulic sprayer, at 500 pounds pressure, using a gun. Weather conditions -- high winds and frequent rains during March, April and May -- made spraying dif-

Table 2. Control of apple scab and cracking, Blaxtayman variety, University Farm, Newark, Delaware, 1953.

Treatment	Spray Schedule[a,b,c] Time	Concentration (lbs.--gals.)	Scab[d] (%) Oct. 9	Cracking[d] (%) Oct. 9	Finish Rank[e]
No Fungicide	Pre-Pink--1st C.	---			
Bordeaux	2nd Cover--7th C.	1-3-100	52	59[f]	4
Mag. 70 Sulfur	Pre-Pink--1st C.	8,7,5-100	7	52	5
Ferbam	2nd C.--4th C.	1½-100			
Ferbam	5th C.--7th C.	1-100			
Mag. 70 Sulfur	Pre-Pink--1st C.	8,7,5-100	18	53	3
Zineb[g]	As for Ferbam	As for Ferbam			
Mag. 70 Sulfur	Pre-Pink--1st C.	8,7,5-100	7	49	3
Captan	As for Ferbam	As for Ferbam			
Mag. 70 + Zineb	Pre-Pink--1st C.	4-1-100	11	34	2
Zineb	As for Ferbam	As for Ferbam			
Mag. 70 + Captan	Pre-Pink--1st C.	4-1-100	4	28	2
Captan	As for Ferbam	As for Ferbam			
Zineb + Captan	Pre-Pink--1st C.	1-1-100	10	30	1
	2nd C.--4th C.	3/4-3/4-100			
	5th C.--7th C.	1/2-1/2-100			
L.S.D. @ 5% P			9	14	
L.S.D. @ 1% P			12	19	

[a] Delayed Dormant Applications: Bordeaux (2-2100) and Superior Oil (2%).

[b] Test Materials Applied: Pre-Pink (Apr. 10); Pink (Apr. 16); Full Pink (Apr. 24); Petal Fall (May 1); 1st Cover (May 8); 2nd Cover (May 19); 3rd Cover (June 2); 4th Cover (June 15); 5th Cover (June 30); 6th Cover (July 13); 7th Cover (July 27).

[c] Insecticides Added: BHC (2 1/2-100) at Full Pink. Lead Arsenate (3-100) at Petal Fall, 1st Cover, 2nd Cover; (added Lime (3-100) to Sulfur plots at Petal Fall and 1st Cover). Parathion (3/4-100) at Petal Fall and 1st Cover. DDT (2-100) at 2nd, 3rd, 4th, 5th, 6th, and 7th Covers, and again on Aug. 11. Aramite (1 1/2-100) at 6th Cover and again on July 21. TDE (1 1/2-100) on Aug. 11.

[d] Based on 250 fruits for each of four replicate trees at harvest.

[e] Based on visual examination.

[f] Due mainly to primary scab infection.

[g] Zineb was from Dithane Z-78.

ficult, and poor coverage and wind-blown drift resulted.

The incidence of both fire blight and frog-eye was much lower than in 1952, whereas scab was much higher. Fire blight and frog-eye counts were made on May 14 and June 12, the trees being scored on the basis of 0 (no infection) to 10 (100 percent infection). Scab counts were made at harvest, July 2, using 250 apples per tree. Complete data are shown in Table 1, with data for 1952 included for comparison.

The 1953 data in Table 1 show that:

1. No significant results were obtained on fire blight control owing to the low incidence and variability of the disease.
2. All fungicides gave significant control of frog-eye leafspot, whereas the antibiotics used were ineffective.
3. All fungicides gave excellent control of scab. Thiolutin was the only antibiotic to give significant control.

Observations on fruit finish at harvest show that ferbam[8] was the only material to cause

[8] ferbam -- ferric dimethyldithiocarbamate.

Table 3. Control of Brook's spot (Jonathan variety) and scab (Red Delicious and Stayman varieties), University Farm, Newark, Delaware, 1953.

Treatment	Spray Schedule[a, b, c] Time	Concentration (lbs.-gals.)	Brook's Spot (Jonathan) Ground (%)	Brook's Spot (Jonathan) Tree (%)	Scab Red Del. (%)	Scab Stayman (%)	Finish[d] Red Del. (Rank)
Untreated	-----	--------	36	47	88	62	4
Mag. 70 Sulfur Ferbam	Pre-Pink--1st C. 2nd Cover--4th C. 5th Cover--7th C.	8,7,5-100 1½-100 1-100	0	0	3	1	5
Captan	Pre-Pink--1st C. 2nd Cover--4th C. 5th Cover--7th C.	2-100 1½-100 1-100	1	1	1	0	3
Zineb[e]	Same as for Captan above		6	5	6	3	2
Captan + Zineb	Same as for Captan above[f]		1	0	2	2	1
Captan Zineb Captan Zineb	Pre-Pink--Pink Full Pink--1st C. 2nd Cover--4th C. 5th Cover--7th C.	2-100 2-100 1½-100 1-100	2	1	2	1	1
L.S.D. @ 5% P			11	--	7	--	
L.S.D. @ 1% P			15	--	10	--	

[a] Delayed Dormant Application: Bordeaux (2-2-100) and Superior Oil (2%).

[b] Test Materials Applied: Pre-Pink (Apr. 10); Pink (Apr. 16); Full Pink (Apr. 24); Petal Fall (May 1); 1st Cover (May 11); 2nd Cover (May 19); 3rd Cover (June 2); 4th Cover (June 17); 5th Cover (July 3); 6th Cover (July 15); 7th Cover (July 29).

[c] Insecticides Added: BHC (2 1/2-100) at Full Pink. Lead arsenate (3-100) at Petal Fall, 1st and 2nd Covers. EPN (3/4-100) at Petal Fall, 1st Cover. Parathion (2-100) at 2nd Cover. DDT (2-100) at 2nd, 3rd, 4th, 5th, 6th, and 7th Covers, and Aug. 11. Aramite (1 1/2-100) at 6th Cover (July 15) and again on July 22. TDE (1 1/2-100) was used on Aug. 11.
NOTE: Where lead arsenate was used, lime was used only on the untreated and sulfur-treated trees.

[d] Based on visual examination (average scoring by 4 people).

[e] Zineb was Dithane Z-78.

[f] Each material was used at half-strength in combination.

injury (black flecking on the sunny side of the apples).

Blaxtayman Variety, Newark (scab, cracking and fruit finish): This experiment was conducted, primarily, to obtain information on various sulfur-organic fungicide programs for the control of scab. Each treatment was applied to two single-row plots (17 trees each) of 17-year-old trees, using a Bean "Low Boy" sprayer delivering 500 pounds pressure. At harvest, October 9, scab and cracking counts were made on 1000 fruits from each treatment; also, fruit finish was determined by visual inspection. Complete data are presented in Table 2.

The data in Table 2 show that:

1. All materials and schedules gave control of scab, but those schedules containing zineb were the least effective.
2. Schedules containing full-strength Magnetic 70 sulfur paste through the First Cover application resulted in significantly more cracking than schedules containing half-strength sulfur in combination with zineb or captan.
3. The best fruit finish resulted from the schedule employing half-strength zineb and captan; the next best finish was with schedules containing half-strengh sulfur combined with zineb or captan; the poorest finish resulted from the use of full-strength sulfur followed by ferbam.
4. The schedule of half-strength zineb and captan throughout the season was worthy of further consideration.

Table 4. Control of sooty blotch, scab, and fruit rots on the Rome variety, Bridgeville Delaware, 1953.

Treatment[1]	Spray Schedule[a, b, c,] Time	Conc. (2X)	Disease Incidence (%)[d, e] Scab 10/1	Scab 10/8	Sooty Blotch 10/1	Sooty Blotch 10/8	Fruit Rots 10/1	Fruit Rots 10/8
Unsprayed		----	54	57	91	98	7	11
Mag. 70 Sulfur + Parzate Parzate[e] Bordeaux	Pre-Pink--Pink	8-2-100	0	1	46	34	0	0
	Full Pink--1st C.	4-100						
	2nd Cover--8th C.	2-6-100						
Mag. 70 Sulfur + Captan Parzate[e]	Pre-Pink--Pink	8-1-100	1	1	4	1	1	1
	Full Pink--7th C.	4-100						
	2nd Cover--4th C.	3-100						
	5th Cover--8th C.	2-100						
Mag. 70 Sulfur + Captan Captan	Pre-Pink--Pink	8-1-100	1	1	47	51	0	0
	Same as for Parzate above							
Parzate[e]	Pre-Pink--1st C.	4-100	2	1	1	1	1	0
	2nd Cover--4th C.	3-100						
	5th Cover--8th C.	2-100						
Dithane Z-78[e]	Same as for Parzate above		4	3	1	1	1	1
Captan	Same as for Parzate above		2	2	64	58	0	0
L.S.D. @ 5% P			--	--	7	11	-	--
L.S.D. @ 1% P			--	--	9	15	-	--

[a] Parzate, Dithane Z-78 = zineb.

[b] Delayed Dormant Application: Bordeaux (2-2-100) and 2% Superior Oil.

[c] Spray Applications: Pre-Pink (Apr. 9); Pink (Apr. 16); Full Pink (Apr. 23); Full Bloom (Apr. 28); Petal Fall (May 5); 1st Cover (May 12); 2nd Cover (May 21); 3rd Cover (June 2); 4th Cover (June 16); 5th Cover (June 30); 6th Cover (July 14); 7th Cover (July 18); 8th Cover (Aug. 20).

[d] Insecticides Added: Lead arsenate (3-100) Petal Fall, 1st Cover. EPN (3/4-100) Petal Fall, 1st Cover. DDT (2-100) 2nd, 3rd, 4th, 6th, and 8th Covers. TDE (1/2-100), 7th Cover. Mite Control -- During the season, several separate applications were made by the grower using Ovotran, EPN 300, and Sulfenone.

[e] The fruit counts on October 1 are based on 100 fruits on each of 4 trees, 50 fruits being taken from 1 foot to 3 feet above ground, and 50 at eye level; the counts on October 8 are based on 150 fruits per tree, 75 fruits at 1 foot to 3 feet above ground, and 75 at eye level. At each count, fruits were scored at four stations on each tree.

[f] Finish: In descending order, based on visual examination: captan, zineb, Bordeaux, and untreated. However, there was little difference between the captan and zineb fruit.

Jonathan, Red Delicious, and Stayman Varieties, Newark (scab, Brook's spot, and fruit finish): This experiment was designed to evaluate zineb and captan used alone, in combination, and in alternation on several varieties for control of various diseases and for their effect on fruit finish. For the purposes of comparison, the former standard schedule of Magnetic 70 sulfur paste followed by ferbam was included. Six single-tree plots were used for each treatment on each of the three varieties (12-year-old trees). Spraying was done with a hydraulic power sprayer, at 500 pounds pressure, using a gun. Significant data were obtained on control of Brook's spot (Mycosphaerella pomi) on the Jonathan variety and of scab on the Red Delicious and Stayman varieties. Brook's spot data were taken on dropped fruit on September 10 and on fruit on the tree at harvest, September 15; scab data were obtained just before harvest on the Red Delicious and Stayman varieties (September 10 and October 1, respectively). Complete data are shown in Table 3.

The data in Table 3 show that:

1. Captan and zineb, in all schedules, gave control of Brook's spot and scab.
2. Captan, used alone, was slightly more effective than zineb, used alone, for control of both diseases.
3. Captan plus zineb (half-strength of each) and captan alternating with zineb gave control of both diseases.
4. The best fruit finish was produced by captan plus zineb (half-strength of each) and by captan alternating with zineb.
5. The former standard schedule of Magnetic 70 sulfur paste followed by ferbam gave its usual excellent control of both diseases, but resulted in the poorest fruit finish.

Rome Variety, Bridgeville (scab, sooty blotch, and fruit rots): The block for this demonstration-experiment was selected since it had suffered approximately a 75 percent loss of fruit in 1952 due to the following diseases: scab, fire blight, cedar rust, black rot, Botryosphaeria rot (Botryosphaeria ribis), and sooty blotch. It contains 24 rows, each with 22 trees (15 years old). Each material, at 2X concentration, was applied to four rows of trees with a speed sprayer equipped with four Aqua-Jet nozzles; four trees were left unsprayed as controls. When the trees were in full-leaf, 5.5 gallons of spray were applied per tree. A total of 13 applications were made, beginning with the Pre-Pink (April 9) and ending with an Eighth Cover (August 20).

On May 18, it was found that foliage of the zineb-sprayed trees (Dithane Z-78 and Parzate) had a conspicuous purple flecking. This injury was considered to have been caused by some incompatibility of zineb with the lead arsenate used in the Petal Fall (May 5) and First Cover (May 12) applications; no lime had been included. This injury was not found in the captan block, and a state-wide survey on May 19 showed that it was confined to the Rome variety only. During July, August and September, the zineb-sprayed trees showed some yellowing of the foliage, whereas captan-sprayed trees did not.

Scab developed fairly extensively on the unsprayed trees, and fruit rots to some extent; fire blight and cedar rust did not appear in measurable amounts. Late in August, after the last spray, sooty blotch developed extensively on the untreated and captan-sprayed trees. Just before harvest, two counts were made on fruit for scab, sooty blotch and fruit rots. Complete data are listed in Table 4.

The data in Table 4 show that:

1. All materials controlled scab and fruit rots; however, the incidence of the latter was too low for the control data to be of much value.
2. The zineb fungicides (Dithane Z-78 and Parzate) gave excellent control of sooty blotch, whereas captan and Bordeaux mixture were ineffective.

The results on captan are in accord with those reported by Groves (2, 3).

1954 Tests

Three experiments were carried out; but, owing to drought conditions, significant disease data were obained only in the test on the Rome variety.

Rome Variety, Bridgeville (sooty blotch and Botryosphaeria rot): The objective of this experiment was to obtain information on captan and zineb, used alone and in combination, during the period covered by the Fourth Cover (June 21) through the Eighth Cover (August 23) applications. The same block of 16-year-old trees was used as in 1953. Each material, at dilute concentration, was applied to a block of 4 rows (22 trees per row), using a speed sprayer; approximately 9 gallons of spray per tree were applied when the trees were in full foliage. Four trees in one corner of the block were left unsprayed. Botryosphaeria rot appeared in late July and developed slowly until harvest (October 14); sooty blotch did not appear until late September. Complete data are presented in Table 5.

The data show that captan failed to control sooty blotch whereas both zineb and the combination of captan plus zineb gave significant control. All three materials gave good control of Botryosphaeria rot.

1955 Tests

The 1955 season, in spite of the long, hot, dry period during all of July and early August,

Table 5. Control of sooty blotch and Botryosphaeria rot, Rome variety, Bridgeville, Delaware, 1954.

Treatment	Spray Schedule[a] Time	Conc.	Fruit Infection (%)[b] Sooty Blotch	Botryosphaeria
Unsprayed			27	37
Captan	4th C.--8th C.	1½-100	25	6
Zineb[c]	4th C.--8th C.	1½-100	11	9
Captan + Zineb	4th C.--8th C.	3/4-3/4-100	7	7
L.S.D. @ 5% P			7	5
L.S.D. @ 1% P			9	7

[a]Application Dates: 4th Cover, June 21; 5th Cover, July 10; 6th Cover, July 24; 7th Cover, Aug. 6; 8th Cover, Aug. 23. DDT (2-100) was the insecticide used in all Cover sprays.
[b]At harvest, Oct. 14.
[c]Zineb was Dithane Z-78.

Table 6. Control of sooty blotch, fly speck, black rot, and Botryosphaeria rot, Rome variety, Bridgeville, Delaware, 1955.

Treatment[a]	Concentration (lbs.-gals.)	Fruit Infection (%)[b] Sooty Blotch	Fly Speck	B. ribis	Black Rot	Residue at Harvest[c] (ppm) Captan	Zineb
Unsprayed		40	51	58	32	----	----
Captan	1½-100	27	4	15	4	0.4	----
Zineb[d]	1½-100	12	0	9	3	----	5.6
Captan + Zineb	3/4-3/4-100	11	1	12	4	0.2	1.5
Captan & Zineb (alternating)	1½-100	9	1	13	6	0.3	1.8
L.S.D. @ 5% P		13	9	7	5		
L.S.D. @ 1% P		18	12	10	7		

[a]Application Dates: 4th Cover, June 24; 5th Cover, July 8; 6th Cover, July 22; 7th Cover, Aug. 5; 8th Cover, Aug. 19. DDT (2-100) was the insecticide used; TDE (1 1/2-100) was used also at the 5th and 6th Covers.
[b]Based on 250 fruits on each of 4 trees at harvest, Oct. 11.
[c]Tolerances: captan, 20 ppm; zineb, 7 ppm. Residues were determined by the chemical companies supplying materials. Rainfall from the 8th Cover (Aug. 19) to harvest (Oct. 11) totaled 5.61 inches.
[c]Zineb from Dithane Z-78.

was an extremely favorable one for the development of both sooty blotch and Botryosphaeria rot because of heavy hurricane rains during mid-August. Since these rains came after the last spray had been applied (August 3) on all varieties except Rome, an excellent opportunity was presented to evaluate the control afforded by the fungicides under conditions extremely favorable for disease development. Excellent data was obtained in two experiments.

Rome Variety, Bridgeville (sooty blotch, fly speck, Botryosphaeria rot, and black rot): This experiment was conducted in the same block of 17-year-old trees used in 1954 and 1953. The object was to obtain further control data on captan and zineb used alone and in combination; an alternating schedule of captan and zineb was also tested. The fungicides were applied

Table 7 Evaluation of captan and zineb used alone, in alternation and in combination on the Red Delicious (R.D.), Golden Delicious (G. D.) and Stayman (St.) varieties for sooty blotch control, russeting, cracking and fruit finish, University Farm, Newark, 1955.

Material	Spray Schedule[a, b, c] Time	Conc.	Sooty Blotch (%) R.D.	G.D.	St.	Russeting (%) R.D.	G.D.	St.	Cracking (%) St.	Finish Rank[d]
Untreated	----	----	33	48	85	4	12	4	4	5
Zineb[e]	P.P.-2nd C 3rd C-7th C	2-100 1½-100	1	6	12	14	26	5	18	4
Captan[e]	P.P.-2nd C 3rd C-7th C	2-100 1½-100	15	44	42	7	16	5	12	1
Captan Zineb Captan Zineb	P.P.-Pink F.P.-1st C 2nd C-3rd C 4th C-7th C	2-100 2-100 2-100 1½-100	2	10	9	11	17	4	21	2
Captan Captan + Zineb	P.P.-Pink F.P.-2nd C 3rd C-7th C	2-100 1-1-100 3/4-3/4-100	2	9	16	9	14	4	14	1
L.S.D. @ 5% P			9	18	18	-	-	-	-	
L.S.D. @ 1% P			13	25	24	-	-	-	-	

[a]Dormant Spray: Superior Oil, 2%. Delayed Dormant Spray: Bordeaux, 2-2-100 (Apr. 3)
[b]Test Materials Applied: Pre-Pink (Apr. 13); Early Pink (Apr. 16); Full Pink (Apr. 21); Bloom (Apr. 26); Petal Fall (May 4); 1st Cover (May 13); 2nd Cover (May 24); 3rd Cover (June 7); 4th Cover (June 22); 5th Cover (July 6): 6th Cover (July 20); 7th Cover (Aug. 3).
[c]Insecticide Sprays: BHC (2 lbs.), Early Pink. Lead Arsenate (2 lbs.), Petal Fall, 1st, 2nd Cover. TDE (1 1/2 lbs.), 1st and 5th Covers. DDT (2 lbs.), 2nd through 7th Covers. Aramite (1 1/2 lbs.), 7th Cover. Ovotran (1/2 lb.), 7th Cover. Systox (1 pint), May 18.
[d]Based on visual examination (average rating by 4 people).
[e]Zineb from Parzate; captan from Captan 50W.
NOTE -- Rainfall (inches): April, 2.84; May, 0.98; June, 6.84; July, 0.23; August, 13.14; September, 1.42.

during the period covered by the Fourth Cover (June 15) through the Eighth Cover (August 19) applications. Each material, at dilute concentration, was applied to a block of 4 rows (22 trees per row), using a speed sprayer; approximately 8 gallons of spray were applied per tree per application. The same four trees left unsprayed in 1954 and 1953 were again unsprayed in 1955. Previous to the Fourth Cover, the block of trees had received a captan schedule. All four diseases developed extensively after the hurricane rains in mid-August. Complete data are presented in Table 6.

These data confirm those obtained on the Rome variety in 1954 and 1953, showing that captan failed to control sooty blotch whereas zineb and the combination of captan plus zineb gave control. All materials gave good control of the fruit rots. Of considerable interest is the differential action of captan in the control of fly speck and sooty blotch.

The data on residue show that use of the captan and zineb combination results in residues far below the established permitted tolerances for each.

Red Delicious, Golden Delicious, and Stayman Varieties, Newark, (sooty blotch and fruit finish): The object of this test was to obtain further information on the relative effectiveness of captan and zineb used alone, in alternation, and in combination for disease control, and on their effect on fruit finish. The materials were applied to the same trees used in 1954. Replicated, randomized 4-tree plots were used. Spraying was done with a Bean "Low-Boy" hydraulic power sprayer delivering 500 pounds pressure. A total of 12 test applications was made, beginning at Pre-Pink (April 13) and ending with the Seventh Cover (August 3) application. Except where otherwise noted, all insecticides were applied jointly with the fungicides. After the hurricane rains in mid-August, sooty blotch developed extensively on all three varieties.

Sooty blotch, russeting, cracking and fruit-finish data were taken at harvest on each

variety -- Red Delicious September 25, Golden Delicious September 29, Stayman October 6. Counts were made on 250 fruits on each of 4 trees for each treatment on each variety. Complete data are presented in Table 7.

The data in Table 7 on sooty blotch control confirm those obtained on the Rome variety for the period 1953-1955 inclusive; namely, that captan is ineffective for control whereas zineb, used alone or in combination with captan, is effective for control. The data on russeting and cracking show that zineb caused more injury than captan, that the combination of captan and zineb was comparable to captan alone, and that the alternating schedule of captan and zineb was comparable to zineb alone. The data on fruit finish show that the combination of captan and zineb produced fruit having excellent finish, as good as captan used alone and superior to that produced by zineb used alone.

Stearns et al. (15), of the Entomology Department, determined the finish rating of the apples in this experiment by means of a glossmeter (1). Data obtained showed that the apples sprayed with the combination of captan and zineb had the highest rating, indicating the best finish. Similar results were obtained in an experiment conducted at the University Substation, Georgetown, Delaware, in which the same fungicides were used.

SUMMATION

Under the conditions of the experiments reported herein, data obtained on the relative effectiveness of captan and zineb, used alone and in alternation and combination, for the control of several diseases show the following:

Scab: Captan was more effective than zineb; the combination of captan plus zineb was intermediate between captan and zineb.

Fire Blight: Zineb gave fair control in 1952; captan was not used. In 1953, the incidence of fire blight was too low for significant data to be obtained.

Frog-eye Leafspot: The 1953 data show that captan, zineb, and the combination of captan and zineb were all equally effective in control.

Brook's Spot: Captan and zineb used alone, in combination and in alternation gave significant control; captan alone was better, but not significantly so.

Sooty Blotch: Captan failed to control this whereas zineb gave excellent control. Where captan and zineb were used in combination or in alternation, control was approximately equal to that where zineb was used alone.

Fly Speck: Captan, zineb, the combination of captan and zineb, and captan and zineb used in alternation all gave control.

Botryosphaeria ribis Fruit Rot: Captan, zineb, the combination of captan and zineb, and captan alternating with zineb were all equally effective in control.

Black Rot: Control results were essentially identical for all materials.

Cracking: Captan caused less cracking of Stayman apples than zineb but the difference was not significant. The combination of captan and zineb produced less cracking than zineb, but more than captan; however, results were not significant.

Russeting: Captan caused less russeting on Red Delicious and Golden Delicious apples than zineb, but the difference was not significant. The combination of captan and zineb, and captan and zineb used in alternation, caused less cracking than zineb and more than captan; however, results were not significant.

Fruit Finish: The combination of captan and zineb produced fruit having the highest finish, whether rated visually or by means of a glossmeter. Captan used alone, and when used in alternation with zineb, was almost equal to the combination of captan and zineb. Zineb alone, particularly in 1955, was not equal to captan in finish.

Residue Data: Data show that captan residues were quite low whereas those of zineb were quite high. This may account for the failure of captan to control sooty blotch. Residues for both materials were under the established permitted tolerances. Residues for the combination and alternating schedules of captan and zineb were lower than where each material was used alone, which indicates that their use should not result in a residue problem.

CONCLUSIONS

From the evidence reported, it is apparent that captan possesses certain advantages over zineb, particularly for scab control and fruit finish; contrariwise, zineb possesses certain advantages over captan, particularly for sooty blotch and rust control and possibly for fire blight control. Neither material used alone is completely satisfactory as an all-season spray.

The combination of captan and zineb (half-strength of each) gave control of all the diseases present and produced fruit having the highest finish. Thus the combination obviated the disadvantages of each material used alone. To all intents and purposes, the alternating schedule of captan and zineb was equal to the combination of the two, except possibly for fruit finish. However, the combination of captan and zineb should be easier to handle by fruit growers from an operational standpoint.

The combination of captan and zineb (half-strength of each) should have a definite place in the late-cover-spray period on apples since it has given excellent control of all diseases usually of consequence at that time, has been non-injurious, has produced fruit having the best finish, and has resulted in residues well below the established tolerances for both captan and zineb. The combination should also have a place in the period covered by the full pink through first cover applications on apple varieties where cedar rust and fire blight diseases are of concern. Zineb alone, at full-strength, may be used in place of the combination of captan plus zineb, but its use may result in some diminution in fruit finish.

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DEPARTMENT OF PLANT PATHOLOGY, DELAWARE AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF DELAWARE

PRELIMINARY NOTE ON THE DOWNWARD MOVEMENT OF STREPTOMYCIN[1] IN APPLE AND PEAR TISSUES

John C. Dunegan and R. A. Wilson

In a previous note[2] we reported that streptomycin produced chlorotic spots on Bartlett pear leaves when applied as a spray. Likewise we got different chlorotic patterns on leaves when 50 mg. of streptomycin was inserted in the trunk of a young Elberta peach tree. These results indicated 1) absorption of the chemical through the epidermis of the leaves and 2) the upward translocation of it or some by-product from it through the vascular system of the tree. Both types of applications are open to the same criticism: namely, they furnish no precise quantitative data on the actual amount of material required to produce the toxic symptoms noted.

In April 1956 a series of experiments was initiated on fully expanded apple and pear leaves by use of a modification (substitution of drinking straws for glass tubes to hold the thread wicks and the solutions) of the procedure described by Roach[3] on page 23 of his classic paper on plant-injection procedures and illustrated in his Figure 4E. A standard amount (0.25ml.) of solution was used in each drinking straw cylinder and the effects of streptomycin solutions containing .000025 to .00125 gm. of streptomycin were tested. The amounts used were purposely kept at toxic levels to induce symptoms on the leaves.

We found that the intensity of symptoms varied with the amount of streptomycin introduced. The symptoms were the same on apple and pear leaves. Moreover, by limiting the site of injection to an individual leaf we were able to make certain other pertinent observations, as follows:

1. If the leaf was punctured and the wick inserted in an interveinal area, a chlorotic spot developed similar to the symptom noted on leaves of apple and pear trees sprayed with streptomycin solutions.
2. If the puncture was made through the petiole at the base of the leaf blade an entirely different symptom developed. Instead of producing a chlorotic spot the material made the veins chlorotic and diffused into the adjacent tissue producing a chlorotic band of varying width parallel to the veins.
3. If the puncture was made adjacent to one of the larger veins in the leaf a combination of mesophyll and vascular symptoms developed. The spot involving the mesophyll tissue developed in the immediate vicinity of the puncture, but the veins on the half of the leaf blade were outlined and chlorotic as when the puncture was made through the petiole.
4. Finally, if the puncture was made through the petiole at the base of the leaf blade vascular symptoms developed first on leaves at the growing point 4 to 8 nodes above the treated leaf and subsequently appeared on leaves 2 to 4 nodes below the treated leaf. The treated leaf eventually became chlorotic throughout.

These results are of particular interest as they indicate that streptomycin or some by-product from it can diffuse downward as well as upward under the conditions used. The upward movement was observed in our preliminary experiments in 1953, but this is the first evidence we have seen of the downward movement of streptomycin or its by-products in apple or pear tissues. The movement of streptomycin or its by-products is best demonstrated on trees with actively growing terminal shoots.

UNITED STATES DEPARTMENT OF AGRICULTURE, AGRICULTURAL RESEARCH SERVICE, HORTICULTURAL CROPS RESEARCH BRANCH, BELTSVILLE, MARYLAND

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[1] Chlorotic symptoms developed on leaves when streptomycin was introduced, but there is no proof that the streptomycin molecule moved intact through the leaves of apple and pear. The effects noted might be caused by by-products.

[2] Dunegan, John C., and R. A. Wilson. 1953. Some effects resulting from the introduction of antibiotics into fruit trees. (Abst.) Phytopathology 43: 405.

[3] Roach, W. A. 1938. Plant injection for diagnostic and curative purposes. Imp. Bur. Horticulture and Plantation Crops Tech. Comm. No. 10, illus.

CONTROL OF BACTERIAL WILT OF CUCUMBER BY ANTIBIOTIC SPRAYS[1]

Lansing E. Williams and John L. Lockwood[2]

SUMMARY

Two inoculation methods were used to study the effect of antibiotic sprays on bacterial wilt of cucumber. A leaf-rub method, which consisted of rubbing cucumber leaves with absorbent cotton dipped in water suspensions of Erwinia tracheiphila (E. F. Sm.) Holland, and hypodermic-injection of suspensions into the stems were effective and rapid methods in inducing bacterial wilt.

The incidence of bacterial wilt of cucumber plants, in greenhouse tests, was decreased by sprays of 100 ppm streptomycin or neomycin and by 500 ppm sprays of terramycin or penicillin when applied 24 hours before leaf-rub inoculations were made. In the case of hypodermic-injection inoculations, 100 ppm streptomycin and 500 ppm terramycin were the only sprays reducing the incidence of wilt.

The incidence of bacterial wilt, in the field, was reduced by sprays containing 100 ppm streptomycin and 200 ppm terramycin. Cucumber yields were 25 percent higher in plots sprayed with 500 ppm streptomycin.

INTRODUCTION

Bacterial diseases were not effectively controlled by spraying until the introduction of antibiotics. Recently, several leaf spot diseases have been controlled by these materials. Bacterial wilts have received less emphasis. Natti (5) reported the reduction of bacterial wilt of sweet corn by antibiotic sprays. Winter and Young (7), Goodman (3), Ark (1), and Dunegan et al., (2), and others have successfully controlled fireblight of apple and pear with antibiotic sprays. The effect of antibiotic spray applications on the incidence of bacterial wilt of cucumber is reported in this paper.

Greenhouse Tests

Inoculation Method. -- Artificial inoculations of cucumber plants are commonly accomplished by pricking the stem or leaf with a needle infested with wilt bacteria (4, 6). The authors successfully inoculated cucumber plants by hypodermic injections of bacteria into the stem. The hypodermic method, due to the insertion of the pathogen internally, was not suitable for evaluating the effectiveness of experimental compounds at or near the leaf surface. It was desired to find a rapid method simulating leaf inoculations as accomplished by the striped and spotted cucumber beetles, Acalymma vittata (F.) and Diabrotica undecimpunctata howardi Barber respectively, the natural vectors of the wilt bacterium. This method would not only facilitate evaluation of chemical sprays for the control of bacterial wilt, but results from its use when compared with those from the hypodermic method might give information as to whether an effective material acted systemically or primarily as a surface-protectant.

Different methods of leaf inoculation were studied. The oldest leaf of potted National Pickling cucumbers in the 2-3-leaf stage was rubbed with a piece of absorbent cotton dipped in a suspension of Erwinia tracheiphila. Prior to inoculation, leaves of assay plants were dusted with carborundum, wounded by needle puncture, or left untreated. One-half of the plants in each set were placed in a moist chamber for 24 hours after inoculation. Six plots of 5 plants each were used for each treatment. The bacterial suspensions were prepared from 3-day old nutrient agar cultures of the wilt bacterium grown at 26° C. The suspensions were standardized to 85 percent light transmission using a colorimeter with a 525 μ filter.

All leaf-rub methods attempted were successful in inducing bacterial wilt. There was no advantage in wounding the leaves before inoculation or placing the inoculated plants in a moist chamber. The most efficient of the methods, rubbing the untreated leaves, was used in the

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[2] Present address of John L. Lockwood: Department of Botany and Plant Pathology, Michigan State University, East Lansing, Michigan.

Table 1. Effect of antibiotic sprays on bacterial wilt of cucumber in the greenhouse.

Treatment[b]	Conc., ppm	Number diseased plants[a]	
		hypodermic inoc.	rub inoc.
Streptomycin STS	100	17	8
Streptomycin STS	500	19	0
Sol. Terramycin	100	24	17
Sol. Terramycin	500	16	3
Proc. Penicillin G	100	23	12
Proc. Penicillin G	500	24	10
Neomycin Sulfate	100	25	2
Neomycin Sulfate	500	26	0
Tween 20 control	1000	26	20
No treatment	---	25	21
LSD 5%		7	10
1%		9	13

[a] Total number of plants = 30.

[b] Streptomycin STS containing equivalent of 54% streptomycin base supplied by Merck and Co., Inc. Soluble Terramycin containing equivalent of 21% terramycin base supplied by Chas. Pfizer and Co., Inc. Procaine 55% neomycin base supplied by Upjohn Co. Tween 20 supplied by Atlas Powder Co. Concentrations based on active material.

subsequent greenhouse work. The incidence of disease in plants inoculated by the leaf-rub method was 80 to 100 percent, and did not differ significantly from that of plants inoculated by the hypodermic method.

Bacterial Wilt Control Tests. -- Tests were made to determine whether antibiotic sprays would reduce the incidence of bacterial wilt of cucumber in the greenhouse. Plants were sprayed until run-off occurred, then allowed to dry 24 hours before inoculation. All antibiotic spray materials were carried in 1000 ppm (0.1%) Tween 20. Part of the plants were inoculated by the leaf-rub method; others by hypodermic injection into the stem. Six-pot replications of 5 plants each were used. Two weeks after inoculation the number of diseased plants was determined. Most diseased plants were dead at this time. The antibiotic treatments and data from a typical experiment are in Table 1.

The incidence of bacterial wilt in plants inoculated by hypodermic inoculation was reduced by sprays of 100 ppm streptomycin and by 500 ppm terramycin. All antibiotic sprays, except terramycin and penicillin at 100 ppm, greatly reduced wilt incidence when plants were inoculated by the leaf-rub method. Applications of 500 ppm streptomycin or neomycin gave complete control.

Field Experiment

Following the preliminary greenhouse tests, field plots were established. Ohio MR 17 cucumber seed was planted on June 14 in 4 randomized blocks consisting of 10 one-row treatments. Each row was 54 feet long and contained 18 hills of 4 plants each. The same materials were used in the field test as in the greenhouse experiments. Spray dates were June 21 (coty-

Table 2. Effect of antibiotic sprays on bacterial wilt of cucumber in the field.

Treatment	Conc., ppm	Number diseased plants[a]		Yield, lbs.
		7/30	8/15	
Streptomycin STS	100	47	113	386
Streptomycin SIS	500	22	52	479
Sol. Terramycin	100	36	92	408
Sol. Terramycin	500[b]	13	40	349
Proc. Penicillin G	100	47	109	396
Proc. Penicillin G	500	27	85	391
Neomycin Sulfate	100	29	116	374
Neomycin Sulfate	500	52	125	329
Tween 20 control	1000	39	122	392
No treatment	---	43	109	357
LSD 5%		16	26	50
1%		22	35	67

[a] Total number of plants = 288.

[b] Concentrations reduced to 200 ppm beginning at 4th application, July.

ledonary stage), June 24; July 1, 5, 11, 15, and 29; August 5, 12, 19, and 26. The antibiotics were carried in 1000 ppm Tween 20. Early sprays were applied until run-off with a portable compressed air sprayer. Late sprays were applied with a tractor-mounted sprayer which delivered approximately 160 gallons per acre. No insecticides were used and natural beetle inoculations were sufficient to induce a relatively high incidence of disease.

After 3 applications of 500 ppm terramycin it was evident that although disease incidence was markedly reduced the plants were severely stunted. Consequently, dosages of this material were reduced to 200 ppm. Plants in these rows then resumed vigorous growth and were almost as large as the control plants by the end of the season. Phytotoxicity was not evident on plants sprayed with any of the other treatments.

Ten fruit pickings, beginning August 1, were made at approximately 5-day intervals. All fruits over 2 inches long were removed at each picking. Diseased plants were counted July 30 and August 16. These data are presented in Table 2.

On July 30, the number of diseased plants in rows sprayed with 500 ppm streptomycin or 200 ppm terramycin was one-half to one-third that in the controls. Data taken August 15 showed that 500 ppm streptomycin or 200 ppm terramycin still reduced the number of diseased plants, and that at this date 100 ppm terramycin and 500 ppm penicillin significantly reduced disease when compared to the Tween control, but not the untreated control.

Total weight of fruits harvested was 25 percent higher from plants sprayed with 500 ppm streptomycin than from unsprayed rows. Weight of fruit from rows sprayed with 100 ppm terramycin was significantly higher than that from the untreated, but not the Tween 20 control. Neomycin at 500 ppm significantly reduced yields below those from control rows receiving 1000 ppm Tween 20. Although the total season yield from rows sprayed with 200 ppm terramycin was not increased above the controls, the last 5 pickings were almost identical with those sprayed with 500 ppm streptomycin, the highest yielding rows. If these plants had been sprayed with 200 ppm terramycin at the beginning of the season yields would have exceeded those in control rows and perhaps those from the 500 ppm streptomycin rows also.

DISCUSSION

As in the case of bacterial wilt of sweet corn (5), the mode of action of the antibiotic sprays in reducing bacterial wilt of cucumber is not well understood. In the greenhouse, disease incidence was reduced in plants sprayed with streptomycin or terramycin and inoculated 24 hours later by hypodermic injection of bacteria into the stem. Thus, systemic action by streptomycin and terramycin was indicated. It would also seem reasonable that wilt bacteria might be killed when present on mouth parts or within intestinal tracts of beetles which feed on antibiotic-covered foliage. Bacteria still within beetle lesions at the time of spraying could also be killed. All 4 antibiotics reduced the incidence of wilt in greenhouse tests when plants were subsequently inoculated by the leaf-rub method. If inoculation of cucumber plants by wounding the surface of leaves can be considered as simulating beetle inoculations one might expect those data to be correlated with those from field tests. In the field, however, results more closely resembled those from injection-inoculated plants in the greenhouse.

These results may indicate: a) that systemic action is more important than surface-protective action in the field; or b) that the surface-protective efficiency may be low in the field due to instability of the antibiotics on cucumber leaves or to inadequate coverage, especially of the undersurface of the leaves.

The increase in yields of plants sprayed with streptomycin in this experiment was not sufficient to warrant spraying cucumber plants with this material. If substantial increases in yield could be obtained by fewer applications, or by the use of formulations more effective at lower concentrations, sprays of this material might give economic control of bacterial wilt. Further study of terramycin sprays (100-500 ppm range) is needed before recommendation can be made.

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DEPARTMENT OF BOTANY AND PLANT PATHOLOGY, OHIO AGRICULTURAL EXPERIMENT STATION, WOOSTER, OHIO

A PRELIMINARY REPORT ON THE USE OF MYCOTHRICIN COMPLEX IN PLANTS

G. Rangaswami[1, 2]

SUMMARY

The phytotoxicity of mycothricin complex A was studied by seed germination, foliar spray, and liquid culture methods. The antibiotic was non-toxic to tomato, cucumber, and wheat seeds at 5,000 ppm, to the foliage of the three crops when sprayed at 2,500 ppm, and to the tomato and cucumber seedlings in liquid cultures at 500 ppm. There was also an indication of systemic translocation of the antibiotic in plants. When wheat seeds naturally infested with Helminthosporium sp. and other fungi and bacteria were treated with the antibiotic, there was complete inhibition of growth of the organisms and better germination of the seeds.

INTRODUCTORY

Isolation and characterization of two mycothricin complexes, related to the strepothricin group of antibiotics, are being reported elsewhere (8). The in vitro effect of one of the substances on plant pathogenic bacteria and fungi will be published elsewhere (7). The possibilities of using mycothricin complex A in plants were examined briefly and the results are reported. A partially purified preparation of mycothricin complex A (400 units/mg) obtained from a strain of the Streptomyces lavendulae group was used in all these studies.

SEED TREATMENT

Seeds of tomato, cucumber, and wheat were treated with different concentrations of the antibiotic in water for 1 hour and plated on filter paper in a moist chamber and incubated at room temperature in the light. One hundred apparently healthy seeds were used for each treatment. The percentage germination was recorded after 5 to 10 days (Table 1).

Table 1. Effect of mycothricin complex A on seed germination (% germination).

Concentration mycothricin	Tomato	Cucumber	Wheat
5,000 ppm	91	84	87
2,500 ppm	97	93	93
1,000 ppm	91	93	88
500 ppm	88	87	84
Control	88	88	80

There was no significant difference in the germination percentage due to the treatment. Also, there were no apparent symptoms of stunting of roots or shoots due to the antibiotic treatment as observed after 10 days.

[1] Plant Pathologist, Madras State Government, India. Published with the approval of the Director, Institute of Microbiology, Rutgers University.

[2] The author expresses his appreciation to the members of the Plant Pathology Department of the New Jersey Agricultural Experiment Station for providing facilities to work in their greenhouse.

Table 1. Translocation of mycothricin complex A in plants.

Antibiotic concentration	cut shoots						rooted plants								
	stem			leaf			root			stem			leaf		
	18 hrs	24 hrs	48 hrs	18 hrs	24 hrs	48 hrs	18 hrs	24 hrs	48 hrs	18 hrs	24 hrs	48 hrs	18 hrs	24 hrs	48 hrs
							tomato								
500 ppm	-	+	+	-	+	+	+	+	+	-	+	+	-	-	+
250 ppm	-	-	+	-	-	+	+	+	+	-	-	+	-	-	-
100 ppm	-	-	+	-	-	-	-	+	+	-	-	-	-	-	-
							cucumber								
500 ppm	-	+	+	-	-	+	+	+	+	-	+	+	-	+	+
250 ppm	-	-	+	-	-	-	+	+	+	-	+	+	-	-	+
100 ppm	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-

+ = Inhibition of test organism
- = No inhibition

FOLIAR SPRAY

Seedlings of tomato, cucumber, and wheat were raised in nursery pots in the greenhouse. Starting from the third week, 50 seedlings of each crop were sprayed with successive doses of 500, 1000, and 2500 ppm of mycothricin complex A in water with a week interval between sprays.

In another experiment, 3-week old tomato seedlings were transplanted into 4-inch pots, allowed to set root for 10 days and then sprayed with different concentrations of the antibiotic. The concentrations used were 0, 500, 1000, and 2500 ppm, and eight seedlings were included in each treatment.

In both the experiments no toxic symptoms were observed except in the cucumber seedlings where marginal chlorosis appeared 24 hours after the first spray (500 ppm). The chlorotic spots disappeared after 3 days and subsequent sprays with 1000 and 2500 ppm of the antibiotic did not leave any toxic symptoms.

LIQUID CULTURE STUDIES

Two-week-old tomato and cucumber seedlings raised in nursery pots were transplanted into 250 ml Erlenmeyer flasks containing Knop's solution. After 24 hours the liquid medium was mixed with mycothricin complex A to contain 100, 250, and 500 ppm and the flasks incubated at room temperature in the light. There were no symptoms of toxicity in any of the treatments. When the plants were directly transferred from the nursery pots to the antibiotic solutions at 500 ppm, there was a shock effect in the plants, which was overcome within 2 hours. This shock-effect was not observed at lower concentrations of the antibiotic.

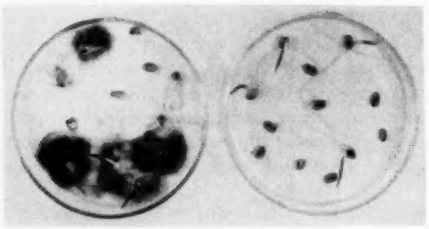
The leaves, stems, and roots of the treated plants were assayed for the presence of the antibiotic by the agar plate method used by other workers (1, 9) with Bacillus subtilis and Saccharomyces cerevisiae as test organisms. Inhibition of growth of the test organism around the treated tissues or the inhibitory effect of the sap from treated plants was taken as an indication of the presence of the antibiotic in the tissue. The tissues and sap from untreated tomato plants, however, were found to be inhibitory to B. subtilis in agar plates but not to S. cerevisiae, whereas there was no such interference in the case of cucumber plants. In the former case an increase in the diameter of the inhibition zone was taken as an indication of the presence of the antibiotic in the tissue. The results of the experiment are summarized in Table 2. The antibiotic appears to be translocated systemically in the plants and could be detected in various parts of the plant 18 to 24 hours after treatment.

TREATMENT OF INFESTED WHEAT SEED

The possibilities of using antibiotics to control seed-borne pathogens have been investigated by various workers (2, 3, 4, 5, 6). In order to evaluate mycothricin in this respect, its effect on

Table 3. Effect of mycothricin complex A on infected wheat seed (100 seeds in each treatment: plated on oatmeal agar).

Concentration of mycothricin	% germination	No. of colonies developing from the seed		
		Helmintho-sporium sp.	Fusarium sp.	Other molds and bacteria
0 ppm	72	73	18	9
500 ppm	72	14	4	12
1,000 ppm	86	4	2	2
2,500 ppm	88	0	0	0
5,000 ppm	86	0	0	0



Untreated Treated (2500 ppm)

FIGURE 1. Effect of mycothricin complex A on fungal and bacterial infestation of wheat seed.

naturally infested wheat seed was studied. Wheat seeds, variety Seneca, obtained from the Farm Crops Department of the New Jersey Agricultural Experiment Station, were examined and found to be infested both externally and internally with Helminthosporium sp. and Fusarium sp., besides other fungi and bacteria. These seeds were treated with 1000, 2500, and 5000 ppm of mycothricin complex A by soaking for 18 hours. The seeds were then dried on sterile filter paper, plated on oatmeal agar medium and incubated at room temperature in the light for 10 days. The germination percentage and development of fungal and bacterial colonies were recorded (Table 3).

There was increased germination of the seeds due to the treatment. The percentage development of Helminthosporium colonies from the seeds was considerably reduced (Fig. 1), thereby indicating that the antibiotic had diffused inside the seed and inhibited the growth of the pathogen, thus effecting increased germination.

DISCUSSION

The antibiotic is comparatively non-toxic as determined by seed germination and foliar spray tests; there were no toxic symptoms at 2500 ppm by spray treatment and 5000 ppm by seed treatment. These concentrations are 50- to 200-fold greater than the inhibitory concentrations of the antibiotic for most plant pathogenic bacteria and fungi (7).

The mycothricin complex also appears to be systemically transmitted in tomato and cucumber plants and to diffuse inside wheat seed. Since these two properties are of extreme importance in using antibiotics in plant disease control, mycothricin warrants detailed investigations in this direction. Furthermore, mycothricin is a water-soluble, basic, and thermostable substance, in which respect it is related to streptomycin, the most successful antibiotic in current use for plant disease control. The combined antibacterial and antifungal properties of the mycothricin complex, and, for that matter, of all the strepothricin group of antibiotics, should be explored for possible use in plant disease control.

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INSTITUTE OF MICROBIOLOGY, RUTGERS UNIVERSITY, THE STATE UNIVERSITY OF NEW JERSEY, NEW BRUNSWICK, NEW JERSEY

A PRELIMINARY REPORT ON THE RESPONSE OF RICE TO SOIL FUMIGATION FOR THE CONTROL OF STYLET NEMATODES, TYLENCHORHYNCHUS MARTINI

John G. Atkins and Max J. Fielding[1]

During 1954-55 rather extensive soil surveys for nematodes were initiated in the rice-growing area of Texas (1, 2). Several genera of parasitic or suspected parasitic nematodes were found in samples consisting of soil and rice roots. As a result of the findings from the survey plans were made for investigating the root parasitic nematodes on rice. As a part of the basic research study soil fumigation tests were planned and conducted in order to determine 1) the effect of nematodes on the growth and yields of rice, 2) the nematocidal efficiency of certain commercial materials, and 3) the dosages of these materials necessary to effect control in the heavy (clay) rice soils of Texas. The chemicals tested in 1955 were methyl bromide (Dow MC-2), ethylene dibromide (Dowfume W-85), Shell D-D Mixture, and Nemagon[2].

The results obtained in 1955 from a test conducted on a commercial rice farm near Anahauc, Texas, were rather interesting. The chemicals were applied on April 4, 1955, in 14 x 20-foot replicated and randomized plots with 4-foot alleys, following thorough soil preparation of the experimental area. The dosages used are listed in Table 1. The methyl bromide was applied under polyethylene covers which were removed after 48 hours. The other chemicals, EDB, D-D, and Nemagon, were applied with a MacLean Fumigun at a 6-inch depth using 12-inch centers. The Nemagon was diluted 1:3 with diesel oil for application. On May 6, the plots were sown with Bluebonnet 50, a representative Texas rice variety. The time and rate of seeding, row spacing, depth of planting, and irrigation (time and depth of flooding) were comparable with commercial practices in the Texas rice area and those at the Rice-Pasture Experiment Station, Beaumont, Texas. Fertilizer was purposely omitted from the plots since it was assumed that injury from nematodes would be more pronounced at lower fertility levels. On September 27, samples from the plots were harvested, permitted to dry, threshed, and weighed.

Table 1. Average number[a] of T. martini per pint of soil.

Treatment	Dosage	Sampling date May 6	June 1	Oct. 28
MC-2	3 lbs./100 sq. ft.	0	0	7
EDB	12 gallons/A.	0	0	16
D-D	40 gallons/A.	3	2	40
Nemagon	5 gallons /A.	66	5	2
Control	---	9	187	80

[a] Average of 3 replications.

The predominant parasitic nematode present in the test area prior to treatment was Tylenchorhynchus martini Fielding 1956. Relatively small numbers of other forms, such as Psilenchus sp., were encountered. Soil samples were taken from the plots on three diferent dates during the course of the test for making nematode counts in the laboratory. A summary of the counts is given in Table 1. As expected, Nemagon did not initially give kill of the nematodes. The nematode counts were somewhat erratic. It is assumed that populations were probably not very uniform in the test area.

All of the nematocidal treatments gave consistent and statistically significant higher grain yields than the check, as shown in Table 2. All of the chemicals used in the test resulted in visual differences in plant growth or appearance, such as foliage color, height, tillering and panicle development. A summary of the measurements and observations is included in Table 3.

In general, the chemicals tested resulted in higher yields, taller plants and better tillering as shown in Tables 2 and 3. The MC-2 plots were conspicuously better in appearance than the

[1] Respectively, Plant Pathologist, Field Crops Research Branch, and Nematologist, Horticultural Crops Research Branch, Agricultural Research Service, United States Department of Agriculture.

[2] Chemicals provided for testing by the Dow Chemical Company and the Shell Chemical Corporation.

Table 2. Average yield[a] of cleaned, rough rice.

Treatment	Pounds/A.	Increase Over Control (lbs./A.)
MC-2	2656.8	826.2
EDB	2462.4	631.8
D-D	2349.0	518.4
Nemagon	2365.2	534.6
Control	1830.6	
L.S.D. .05 = 414.6		
L.S.D. .01 = 603.3		

[a] Average of 3 replications.

Table 3. Effect of nematodes on rice plants.

Treatment	Av. Height (8-17-55) (Inches)	Av. Height (9-27-55) (Inches)	Tillering* (8-17-55)	Av. Panicles per ft. (Number)	Leaf Color
MC-2	41.3	52.5	5.0*	12.7	Dark green
EDB	37.0	47.7	3.7	9.8	Normal
D-D	37.7	47.0	3.7	8.8	Normal
Nemagon	38.3	42.0	3.8	10.1	Normal
Control	34.0	44.2	2.8	9.1	Normal

* Based upon a rating scale of 1 (very poor) through 5 (excellent).

others. This better growth of the rice, as characterized by a darker green color, taller plants and thicker stands, was probably due to better tillering and more vigorous growth of the tillers and less leaf spotting, chiefly because of the absence of Helminthosporium oryzae. The rice in the MC-2 plots showed a slight attack of straighthead, a physiological disease, while the others did not. As the test area was not drained and dried out, the presence of straighthead was not unexpected. The increased yield from the methyl bromide plots probably resulted in part from the control of grasses, particularly barnyard grass (Echinochloa spp.).

Since the number of nematodes in the test area was not particularly high, as shown by counts in the control (Table 1), the improvement in yield and general appearance of the rice in the plots receiving the nematocidal applications was greater than might be expected. The test was located in an area of the Texas rice section in which the rice plants frequently show a root rot or root injury (ordinarily attributed to or associated with root maggots, Lissorhoptrus simplex Say), and the effect of the test chemicals may have been upon a nematode-fungus complex. A hypothesis based upon a nematode-root rot complex might explain the rather marked response of the rice to methyl bromide fumigation.

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FIELD CROPS RESEARCH BRANCH AND HORTICULTURAL CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE COOPERATING WITH THE TEXAS AND LOUISIANA AGRICULTURAL EXPERIMENT STATIONS

EFFECT OF FUNGICIDE AND OF STORAGE TEMPERATURE ON FUNGICIDE INJURY TO WHEAT SEED

Benjamin Koehler and W. M. Bever

Several promising new fungicides for the treatment of small grains have become available since the report on phytotoxicity by the authors (5) in 1954. Treatments with these as well as with some of the well established fungicides were made on good quality commercial seed of Pawnee and Vigo winter wheat, one seed lot of each. Grain moistures before treating were 10.3 and 9.9 percent, respectively. Some treatments increased this amount by 0.5 percent. No data on the pericarp conditions of the seed were obtained. It had been harvested by combine and recleaned in the usual manner. The importance of physical soundness in wheat seed as a preventive for mercury poisoning has been stressed in recent literature (1, 2, 3, 4).

Fungicides intended for use in a slurry machine, i.e., those applied at the rate of 1/2 ounce per bushel or less (Table 1), were applied in slurry or diluted form, and those applied at the rate of 3/4 ounce per bushel were applied in concentrated form. After treating, two 4-ounce bottles were filled and closed tightly with a screw cap. One bottle containing seed from each treatment and an untreated check were stored in the laboratory, except that during the summer they were transferred to a basement with an average temperature of about 70° F. A duplicate set was stored in a refrigerator operating at 40° F. Each set was stored for a 10-month period. Germination tests were made at 70° F in a greenhouse bench containing torpedo sand that had previously been disinfested with formaldehyde. Thus disease control from organisms in the substrate was not confused with phytotoxicity. Seed from two storage temperature conditions for each treatment were planted as a split plot, and there were eight replications of 50 kernels for each item. All sprouts that emerged from the sand in 8 days were counted as stand. If vigor had been considered, differences between chemicals would have been greater than shown, but the order would not have been changed.

The compounds used as fungicidal treatments in this experiment were:

Panogen 15 -- 2.2% methyl mercury dicyan diamide.
Ceresan-M -- 7.7% ethyl mercury p-toluene sulfonanilide.
Ceresan-D -- 2.9% ethyl mercury 2,3-dihydroxy propyl mercaptide plus 0.6% ethyl mercury acetate.
Ceresan-S --7.8% ethyl mercury 2,3-dihydroxy propyl mercaptide plus 1.66% ethyl mercury acetate.
Dupont 244 -- 2.27% phenyl mercuric acetate plus 1.5% ethyl mercury acetate.
Setrete -- 7% phenyl mercuric ammonium acetate.
MEMA-YF-3576 -- methoxy ethyl mercury acetate, 15% mercury. Soluble powder.
MEMB-EMA-BB (350-52) -- methoxy ethyl mercury borate plus ethyl mercury acetate, 2.6% mercury.
MEMA-BB (350-43) -- methoxy ethyl mercury acetate, 3.27% mercury.
MEMA-EMA-BB (350-51) -- methoxy ethyl mercury acetate plus ethyl mercury acetate, 2.56% mercury.
Puraseed -- 6.25% phenyl amino cadmium dilactate plus 6.25% phenyl mercury formamide.

Some investigators reporting on phytotoxicity studies have stated that the mercurial fungicides now in wide use cause no damage when used at the recommended dosage. On the other hand, damage from mercury seed treatment in commercial seed lots of wheat have at times been observed by various people. Crosier and Midyette (1), after testing many treated commercial seed lots, stated that during 1950-1954 several hundred samples of wheat that produced mercury-injured seedlings were observed in tests made at the New York (Geneva) Agricultural Experiment Station Seed Laboratory. They also stated: "Abnormal germination, typical of mercury poisoning was all too common in Virginia" (1954). Factors influencing mercury poisoning in wheat were listed as: moisture, temperature, kind and dosage of fungicide, type and duration of storage, and condition of the seed coats.

When seed treated with volatile fungicide is stored in closed bottles, the fumes are somewhat more intense than those ordinarily occurring in commercial practice. At times, however, seed damage under farm storage conditions in Illinois has been more severe than occurred

Table 1. Stands of two varieties of wheat as influenced by treatment when seed had been stored in closed bottles at two temperatures for 10 months after treating.

Fungicide	Dosage oz./bu.	Percent stand in disinfested sand				Increase in stand due to low temp.		Average percent stand
		Pawnee		Knox				
		70-75°	40°F	70-75°	40°F	Pawnee	Knox	
Untreated check (1)	----	98	98	92	94	0	2	95
Untreated check (2)	----	98	98	92	92	0	0	95
MEMA-YF-3576	1/8	99	98	92	92	-1	0	95
Ceresan-S	1/4	93	98	90	90	5**	0	93*
Panogen 15	3/4	94	98	86	92	4**	6**	92**
Puraseed	1/2	96	98	82	89	2	7**	91**
Ceresan-D	3/4	84	98	83	93	14**	10**	89**
Setrete	1/2	87	92	82	84	5**	2	86**
Ceresan-M	1/2	76	96	74	87	20**	13**	83**
MEMB-EMA-BB	3/4	57	90	59	80	33**	21**	72**
MEMA-BB	3/4	71	65	49	48	-6**	-1	58**
MEMA-EMA-BB	3/4	45	61	35	52	16**	17**	48**
Dupont 244	3/4	8	6	4	2	-2	-2*	5**
Average		77	84	71	77	7**	6**	

* Significance at the 5% level, or ** at the 1% level, for differences in storage temperature, or (in last column) for decrease below the check. Calculations for significance are based on conversion of stand percentages to angles.

with the same fungicide in this experiment. There appears to be no question, other things being equal, that the most desirable seed treating fungicide is the one that has the widest margin of safety. Purdy (6) found no consistent difference in phytotoxicity between three organic mercury compounds when used on wheat. Although his method of experimentation was different, it is not clear why the end result did not agree more closely with those obtained by the writers in experiments at various times (5).

Stands from most of the treatments were significantly lower than the checks, and differences between treatments were striking. Ceresan-S was significantly better than Ceresan-D. Both of these compounds contain the same active ingredients, but the former had been diluted with water so that more liquid was added per bushel, which promoted better mixing with the seed. Furthermore, according to formula, with Ceresan-S somewhat less mercury was added per bushel. Dupont liquid 365, now available commercially, was not available when this experiment was started. No. 365 used at 1/2 ounce per bushel would apply the chemical equivalent of No. 244 used at 3/4 ounce per bushel.

In general, storage of the treated seed at low temperature resulted in the least seed injury. Two compounds that caused considerable seed injury failed to follow this trend. This was true for both wheat varieties, and in two cases where the most damage occurred at the low temperature, the difference was significant. The reason is not known.

It is reported that Ceresan-S and MEMA-YF-3576 will soon appear on the market, the latter under the trade name of Memasol. Experiments on disease control with these two compounds have as yet been limited. All the chemicals listed in Table 1 were used in an oat seed treatment test at Urbana, Illinois, in 1955. Only Puraseed failed to give good smut control. The Ceresan-S now being manufactured has a somewhat lower mercury content than that which was used in these experiments.

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ILLINOIS AGRICULTURAL EXPERIMENT STATION AND THE FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, COOPERATING

A FORTY-TWO YEAR HISTORY OF BUNT IN KANSAS AND A LONG-TIME PROGRAM OF CONTROL[1]

L. E. Melchers, C. L. King, and E. D. Hansing[2]

Summary

A review of the history of bunt control in Kansas shows that definite progress has been made. From 1914 to 1934 (first 21 years) the average annual loss from bunt in Kansas was 2.6 percent or 3,373,000 bushels. From 1935 to 1955 (second 21 years) the average annual loss was less than 1/4 of 1 percent, or 370,000 bushels. Although bunt is always potentially dangerous, the annual loss in Kansas the last 21 years has been minor compared with earlier years. Comparison of the two 10-year periods, 1921-1930 when bunt was a major problem, and 1946-1955 when the disease was well under control, shows a striking contrast. The annual loss in the earlier period averaged 3.7 percent, or 5 million bushels, whereas in the later it was only 0.14 percent, or 27,000 bushels.

Although Kansas produces more wheat than any other State the data show that the annual percentage loss in Kansas from bunt since 1934 has been exceedingly low. This is a direct result of a planned and coordinated program of research and extension work effectively carried to those concerned. The progress is shown to be the result of research on new improved fungicides, the adoption of improved treating equipment, and the breeding of bunt resistant varieties. Comanche was distributed in 1942, Pawnee in 1943, Kiowa in 1950, and Concho in 1954. In 1954 Kansas planted 10,799,000 acres in winter wheat. Bunt resistant varieties were grown on 48.4 percent of this acreage and treated seed was sown on 57.8 percent of the acreage.

Since production of hard red winter wheat began in Kansas, bunt (stinking smut) (Tilletia foetida (Wallr.) Liro) has reduced its yield, grade, and market quality persistently. Bunt is always a potentially dangerous disease.

A paper published in 1950[3] gives information on methods followed in Kansas to reduce loss from bunt. A downward trend in loss was explained as the result of seed treatment, the use of smut-free seed of susceptible varieties, and the breeding of bunt-resistant wheats. Also, a comparison was made of the percentage of cars of Kansas wheat graded "smutty" and "light smutty" at the Kansas City terminal and the percentage of cars at all inspection points in the United States over a period of years.

This paper brings up-to-date the loss that occurred in Kansas from 1914 to 1955, reports the measures used to reduce the loss, and gives an explanation of the low incidence of the disease in the wheat crop during the last 21 years (1935-1955). The reduction of bunt is attributed to a coordinated research and control program widely adopted. Two 21-year periods of the 42 years' data are compared as to the effectiveness of control measures used.

From 1914 to 1926 the yearly monetary loss fluctuated between less than 1/2 million and almost 20 million dollars (Table 1 and Fig. 1). Although seed treatment for prevention of wheat smut was known, it was not consistently practiced. The known seed treatments were not always effective. Wetting or soaking seed was impractical for large acreages and the copper sulfate and formaldehyde methods caused seed injury. Bunt prevention did not seem promising, but because of the war situation in 1917, experiment station workers were faced with the dilemma of choosing between waging a compaign to control bunt with treatments that frequently caused poor stands, or trusting that smut-infested seed might not be too common and that soil temperature and moisture at planting time might be unfavorable for infection by the smut fungus.

The acreages planted with treated seed prior to 1926 were not large (Table 2). Fluctuating

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[1] Contribution No. 610, serial No. 469, Department of Botany and Plant Pathology, Kansas Agricultural Experiment Station, Manhattan.

[2] Plant Pathologist, Extension Plant Pathologist, and Plant Pathologist, respectively, Kansas State College, Manhattan.

[3] Melchers, L. E. 1950. Bunt control in Kansas, a thirty-five year coordinated program. Unnumbered publication issued jointly by Extension Division and Agricultural Experiment Station, Kansas State College, Manhattan.

Table 1. Annual loss from bunt of wheat in Kansas in percentage, bushels, and dollars over 42 years (1914-1955), inclusive.

Year	Percent loss from bunt	Reduction in bushels[a]	Farm value per bu.[a]	Reduction in dollars[b]
1914	0.2	361,000	$0.84	$ 304,000
1915	1.0	961,000	.90	865,000
1916	3.0	3,061,000	1.35	4,133,000
1917	2.5	1,064,000	2.06	2,191,000
1918	3.5	3,373,000	2.00	6,747,000
1919	0.5	733,000	1.98	1,451,000
1920	1.0	1,421,000	1.86	2,642,000
1921	4.0	5,338,000	.97	5,177,000
1922	0.5	587,000	.90	528,000
1923	0.7	537,000	.87	467,000
1924	4.0	6,397,000	1.07	6,845,000
1925	6.0	4,736,000	1.40	6,631,000
1926	10.0	16,661,000	1.20	19,993,000
1927	3.3	3,800,000	1.17	4,447,000
1928	3.2	5,864,000	.94	5,512,000
1929	3.0	4,257,000	1.00	4,257,000
1930	2.0	3,233,000	.63	2,037,000
1931	2.0	4,894,000	.34	1,664,000
1932	2.0	2,171,000	.29	630,000
1933	1.0	583,000	.69	402,000

Table 1. (Continued).

Year	Percent loss from bunt	Reduction in bushels	Farm value per bu.	Reduction in dollars
1934	1.0	805,000	.84	676,000
1935	0.3	180,000	.91	164,000
1936	0.3	362,000	1.01	366,000
1937	1.0	1,596,000	1.04	1,660,000
1938	0.5	764,000	.53	405,000
1939	0.5	561,000	.65	365,000
1940	0.2	248,000	.63	156,000
1941	0.2	347,000	.94	326,000
1942	0.2	401,000	1.09	437,000
1943	0.1	144,000	1.32	191,000
1944	0.1	192,000	1.42	272,000
1945	0.1	208,000	1.49	310,000
1946	0.5	1,089,000	1.91	2,080,000
1947	0.1	295,000	2.67	787,000
1948	0.1	232,000	2.02	469,000
1949	0.1	157,000	1.89	297,000
1950	0.1	178,000	2.02	360,000
1951	0.1	126,000	2.13	269,000
1952	0.05	154,000	2.15	331,000
1953	0.2	290,000	2.01	583,000
1954	0.08	141,000	2.09	295,000
1955	0.08	106,000	2.10	223,000

[a] Calculated on production and value as recorded by H. L. Collins, U.S.D.A. Agricultural Statistician, and Kansas State Board of Agriculture.

[b] Calculated on farm value of actual crop.

Table 2. Kansas wheat acreage planted to treated seed[a].

Fall of:	Acreage	Fall of:	Acreage
1921	171,000	1946	1,694,000
1922	48,000	1947	1,926,000
1923	50,000	1948	2,886,000
1924	72,000	1949	3,997,000
1925	295,000	1950	4,502,000
1926	1,725,000	1951	4,359,000
1927	1,291,000	1952	6,009,000
1928	1,223,000	1953	4,964,000
1929	1,232,000	1954	5,856,000
1930	1,257,000	1955	6,245,000

[a]Data from county agents' annual reports.

Table 3. Seed wheat treating equipment in Kansas and the number of bushels treated.

	Farm treaters		Custom treaters			
Year	Number	Bushels	Portable	Bushels	Stationary	Bushels
1949	5,046	667,000	126	1,211,000	228	1,269,000
1954	5,994	731,000	121	1,037,000	338	3,002,000

Table 4. Effect of seed treatments and resistant varieties on bunt control in Kansas.

	Percent acreage		Average bunt loss	
Years	Treated seed	Bunt resistant varieties	Percent	Bushels
1921-1930	6.1	0	3.70	5,000,000
1946-1955	30.9	47.4	.14	277,000
1955 only	57.8	48.4	.08	106,000

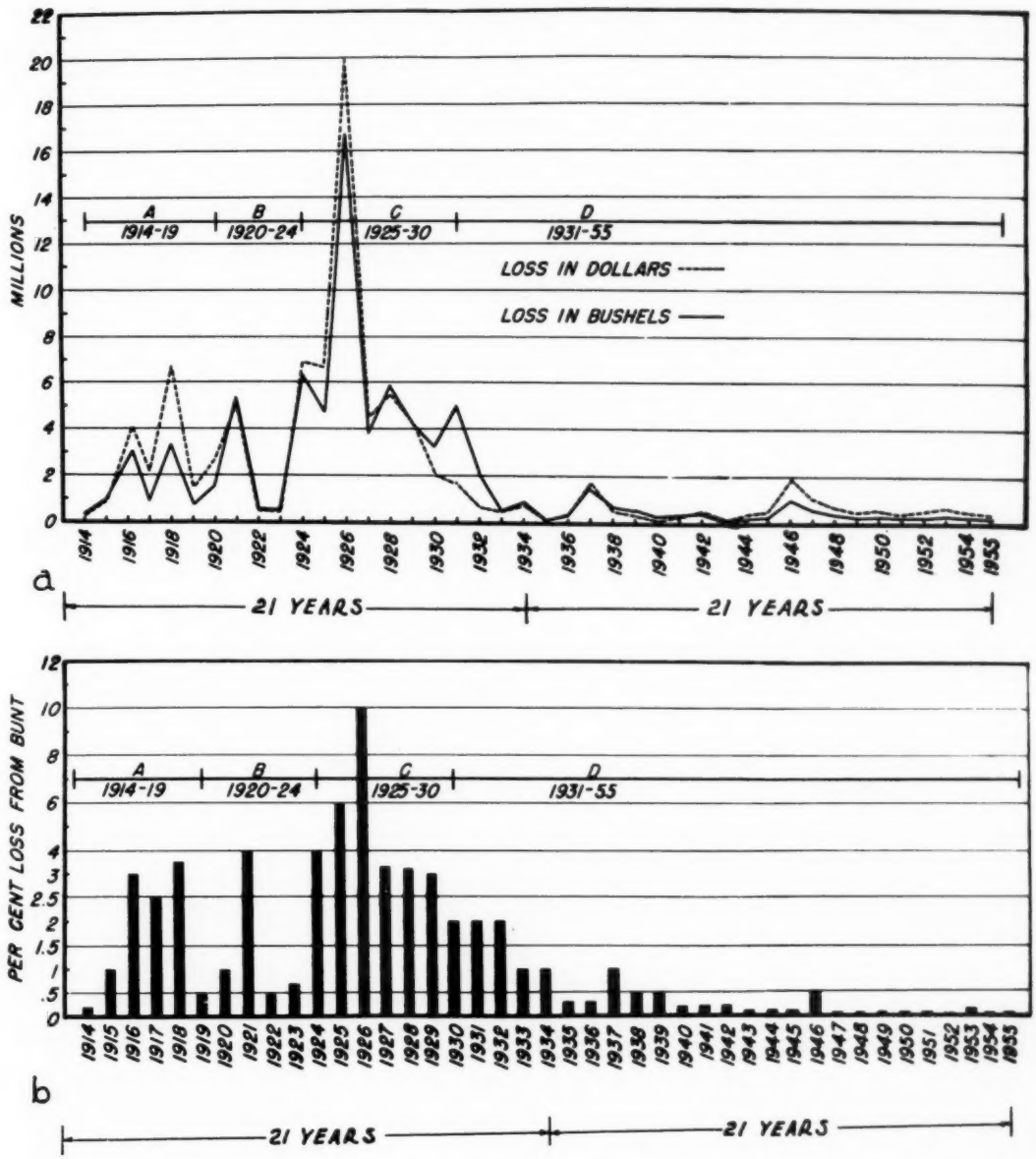

FIGURE 1. Annual loss from bunt in Kansas through 42 years (1914-55): (a) in dollars and bushels; (b) in percentage. A. World War I period; wet formaldehyde, copper sulfate, and hot water treatments the only methods available. B. Studies on copper carbonate as a means of bunt control. C. The 5-year wheat improvement program in Kansas; bunt control by new chemical dust methods emphasized. D. The use of smut-free seed wheat emphasized by the Kansas Extension Service, bunt control by new improved chemical seed treatments widely adopted; the development and release of the resistant varieties Comanche in 1942, Pawnee in 1943, Kiowa in 1950, and Concho in 1954.

losses from bunt resulted from favorable or unfavorable environmental conditions at planting time when smut-infected seed was used. Smut in seed wheat was becoming widespread. With these conditions prevailing, the building up of bunt epidemics to a peak in 1926 was not surprising.

Both Table 1 and Figure 1 show heavy bunt losses in 1925 and 1926 during the Kansas 5-year wheat improvement campaign. This campaign emphasized the need for bunt control and helped get new, practical, chemical dust treatments accepted and used more extensively. Research on better seed treatments for bunt control had been under way, and the use of copper carbonate, which was an efficient, practical, chemical dust treatment that growers could and would use, was recommended in 1925.

Losses from bunt decreased markedly from 1926 to 1935 (Fig. 1). Copper carbonate was effective in controlling bunt and growers were finding it practical to use. They were getting good control by treating approximately 1 1/4 million acres a year. This is shown for 1926 to 1930 in Table 2, which gives acreages planted with treated seed in two 10-year periods representing the earliest records available for the newer better treatments, and the most recent acreages sown with treated seed.

Small annual losses since 1934 demonstrate clearly that the incidence of smut has been kept at a low level. From 1935 to 1955 inclusive (21 years) the average annual loss was less than 1/4 of 1 (0.23) percent, or 370,000 bushles, compared with 2.6 percent or 3,373,000 bushels for the previous 21 years (Fig. 1). Many seasons during the last 21 years provided environmental conditions at planting time highly favorable for bunt. If appreciable quantities of smutty seed of susceptible varieties had been planted under these conditions without treatment, no doubt losses would have been large. During 1921-1930 inclusive, the average annual loss in Kansas was 3.7 percent, or 5 million bushels. In the last 10 years, 1946-1955, it dropped to 1/7 of 1 (0.14) percent, or 277,000 bushels. Bunt has been held near that minimum the last 21 wheat crops, despite large acreages of wheat in Kansas. These results may be attributed chiefly to:

1. Research at the Kansas Agricultural Experiment Station bringing into use more efficient seed treatment fungicides.
2. Proof that seed treatment with recommended fungicides is worth more than its cost because of its effect on stand stabilization even when seed is not bunt-infected.
3. Improved on-the-farm and custom treating equipment.
4. Development and wide use of bunt resistant varieties of wheat in Kansas.
5. Vigorous seed treatment campaigns by the Extension Service every year just preceding wheat seeding time.
6. Use each year of information furnished by the United States Department of Agriculture Marketing Service and by grain companies on the quantities of smutty grain coming to Kansas terminals in July and August. Also a list of the country elevators from which smutty carloads of wheat originate is secured from grain companies each year. This information provides the basis for emphasizing seed treatment in counties or areas in Kansas where bunt has occurred.

These measures need further discussion. Before 1926, seed treatments for bunt control were not generally used in Kansas. Formaldehyde and copper sulfate treatments became obsolete with the advent of the copper carbonate dust method. The adoption and use of this chemical from 1927 to 1934 prevented additional extensive outbreaks of bunt such as occurred from 1924 to 1926.

In the early 1930's Ceresan and New Improved Ceresan became available and were somewhat more effective than copper carbonate[4]. In the late 1940's Ceresan M was introduced and recommended in Kansas. It was less irritating to workers and could be mixed with water and applied to the seed. This greatly lessened the chemical dust hazard to workers. Panogen, an effective liquid fungicide, was tested extensively in Kansas for several years[5, 6, 7], and recom-

[4] Hansing, E. D. 1953. Seed treatment with new as compared with older fungicides for the control of wheat, oat and sorghum smut, and Victoria blight of oats, in Kansas, 1950 to 1952. Plant Dis. Reptr. 37: 49-58.

[5] Hansing, E. D. 1953. Loc. cit.

[6] Hansing, E. D. 1954. Seed treatment with new as compared with older fungicides for the control of wheat, oat, and sorghum smut in Kansas, 1953. Plant Dis. Reptr. 38: 389-392.

[7] King, Claude L. 1953. The effect of fungicidal seed treatment on wheat plant emergence and bunt control. Thesis (unpublished), Kansas State College Library.

mended to wheat growers in 1951. Also Ceresan M-2X, a concentrated dust in a two-unit package with a liquid sticking agent, was put on the market. These two products eliminated the objectionable dust hazard for grain elevators and other organizations doing custom or large-scale seed treating. Experiments over several years with Vancide 51, a nonmercurial liquid of low toxicity, proved it to be highly effective[6]. It has not come into use for treating wheat seed because of its higher cost.

Experiments at Kansas State College [5, 6, 7] showed that treating wheat seed with Ceresan M, Panogen, or Vancide 51 increased stands approximately 10 percent. This means that a grower will get as many plants per acre from 60 pounds of treated seed as from 66 pounds of the same seed not treated. The 6 pounds of seed saved, worth approximately 24 cents, is much more than the 5-cents per bushel cost for seed treatment.

During the past 10 years there has been a great increase in the number of elevators and other organizations in Kansas that clean and treat seed wheat for farmers. The following is a summary of data from the annual reports of Kansas county agents for the past 5 years (Table 3).

The Extension plant pathologist has recommended the use of auger grain loaders for treating seed during the past 5 years. Most wheat growers in Kansas have auger loaders. It has been found that welding a short pipe on top of the auger tube to hold a funnel makes the auger suitable for seed treating. Feeding a suitable fungicide into the funnel as the seed is being augered provides a simple method of treating the seed during loading operations. For treating small quantities some growers use a 30-gallon barrel-type treater.

The number of custom treaters has greatly increased because of the their convenience for growers. Many elevators and other organizations that do custom seed cleaning treat seed without profit for 3 or 4 cents per bushel to encourage growers to treat. The recent development of slurry and Panogen machines that apply fungicides in liquid form has greatly increased seed treatment. These methods remove the chemical dust irritation hazard for the operator, which has been very objectionable in all of the so-called chemical dust treatments.

The Kansas Agricultural Experiment Station has bred and released varieties of wheat that have good bunt resistance. Comanche was distributed in 1942, Pawnee in 1943, Kiowa in 1950, and Concho in 1954. In 1955 these varieties occupied 48.4 percent of about 11 million acres of wheat in Kansas. These varieties are grown in other States also.

Table 4 is a brief summary of the results of bunt control brought about by the use of high yielding bunt resistant varieties and by seed treatments. The data presented are for the same two 10-year periods shown in Table 2.

Each autumn before wheat seeding time a campaign on bunt control is emphasized by the Kansas Extension Service. It consists of: 1) Newspaper and farm magazine articles on the value of seed treatment and on suitable equipment for applying the fungicides; 2) obtaining reports from the grain trade as to the origin of smutty carloads of wheat and asking county agents concerned to stress bunt control in their communities; 3) having county agents display picture posters in their offices, at elevators, banks, and other places frequented by farmers; and 4) radio and television programs by county agents and the Extension plant pathologist. A few years years ago county agents conducted farm demonstration meetings on cleaning and treating seed. These have been replaced largely by television and radio programs and newspaper articles.

DEPARTMENT OF BOTANY AND PLANT PATHOLOGY AND EXTENSION DIVISION, KANSAS STATE COLLEGE, MANHATTAN

FUNGI ASSOCIATED WITH KANSAS HYBRID SEED CORN[1]

L. E. Melchers[2]

SUMMARY

Isolations of fungi associated with Kansas grown hybrid seed corn for the crop years 1952-54, inclusive, showed the presence of one to five species of each of thirteen genera.

Occurrence of certain species of fungi reported earlier in Kansas open-pollinated varieties of corn is compared with that of fungi isolated from hybrid corn grown in Kansas. There are some marked similarities. The most prevalent fungus was Fusarium moniliforme. In 1954 yellow corn hybrid samples had 75.6 percent and white hybrids 69.0 percent of the kernels infected. Considering the three crop years 1952-54, however, all the kernels of white and yellow hybrids cultured from the counties producing hybrid seed corn showed an average of 40.0 percent F. moniliforme. None of the other fungi isolated approached this percentage. This fungus was likewise the most commonly found in Kansas open-pollinated varieties in 1920-22, inclusive. In those years an average of all kernels tested had 94.0 percent F. moniliforme. This fungus is not regarded in Kansas as a pathogen on seed corn.

Diplodia zeae and Nigrospora oryzae are recognized fungus pathogens. In the present investigations they were isolated in small percentages in some hybrid seed samples. Aspergillus niger was isolated in more than usual amounts from kernels of white and yellow hybrids and selfed lines in the crop of 1953. It was referred to as "smut" by seed processors, but it was not the corn smut fungus. Infected kernels were less vigorous in germination than non-infected seed.

All other species of fungi isolated varied in prevalence during a crop year.

The internal fungus flora of seed corn varies according to the area in the United States where corn is grown and the environment in which the seed is matured. Extensive work on the fungi associated with seed corn in connection with seed treatment and disease control has been published. The present study was prompted by the results obtained in Kansas on open-pollinated varieties in 1922 and 1924 (1, 2, 4), in which it was shown that certain fungi were predominantly present on the table seed germinator, while others occurred only occasionally. The most prevalent species in open-pollinated varieties were not considered severely pathogenic and only two species caused appreciable injury (1).

Hybrid seed corn production in Kansas and its use for commercial planting has increased steadily so that today about 98 percent of the corn grown in the State is of hybrid origin, although not all the hybrid seed used is produced in Kansas. This report deals only with the hybrid seed corn produced in those counties of Kansas shown and for the years indicated (Fig. 1 and Table 1).

It was desired to learn which species of fungi are associated with Kansas-grown hybrid seed corn, since no known studies had been made previously. This would show whether any major changes have taken place in the occurrence or prevalence of fungi in seed corn. During the three crop years 1952, 1953, and 1954 rainfall was less than normal for the crop season and drought prevailed at times. This could affect the kind and prevalence of fungi isolated from the seed. For the most part, the counties of Kansas growing hybrid seed corn are confined to the eastern third of the State (Fig. 1).

METHODS

Data are reported on a county basis by years and the samples of various Kansas grown hybrids are represented by both white and yellow corn. Several hundred samples were tested, representing all the seed lots that were available[3]. Each test was represented by 25 kernels, 5 to a Petri dish. The commonest fungus on the surface of the seed corn was Rhizopus nigri-

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[1] Contribution No. 616, serial No. 473, Department of Botany and Plant Pathology, Kansas Agricultural Experiment Station, Manhattan.

[2] Plant Pathologist, Kansas Agricultural Experiment Station.

[3] The hybrid seed corn samples were obtained through the Kansas Hybrid Seed Association and the Kansas Crop Improvement Association, Manhattan, Kansas.

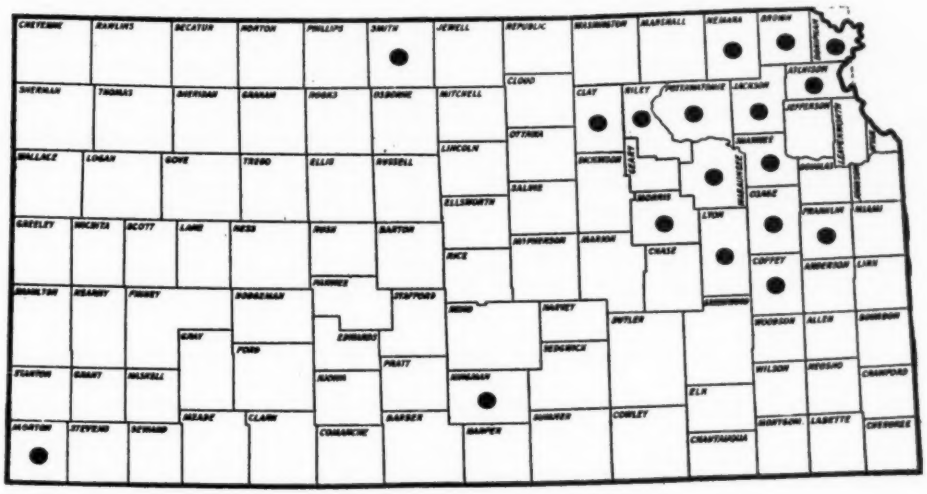

FIGURE 1. Counties in Kansas that produced hybrid seed corn 1952-55 inclusive, and supplied samples for tests.

cans and, in preparing the seed for isolation study, a method of sterilization used completely removed this contaminant, thereby allowing the fungi under the seed coat and in the endosperm to develop. The seed was first washed by agitation for 1 minute in tap water, after which it was surface sterilized in 1% sodium hypochlorite for 2 minutes and then plated out on potato dextrose agar directly without further washing. This method sterilizes the surface but allows organisms to grow that are beneath the seed coat. Treatments of 1% sodium hypochlorite for 2, 3, and 5 minutes were tried and no seed injury resulted. Neither did they prevent the fungi from growing out of infected seed. Since complete surface sterilization was obtained at 2 minutes, this time was used in all of the isolation work.

Petri dishes containing the sterilized kernels were incubated at room temperature, which ranged from about 73° to 80° F. When fungus growth began to appear, daily examinations and readings were made and notes taken on the dish contents. This was followed by isolations, observations on culture growth characteristics, microscopic examinations, and identification. Table 1 lists the genera of fungi and, in three instances, the species that were considered of special interest: namely Diplodia zeae, Nigrospora oryzae, and Fusarium moniliforme.

RESULTS

Thirteen genera of fungi were isolated from 7425 kernels in the 3-year study, being represented by one to five species in each genus. The data show that certain genera and species were much more prevalent and widespread than others (Table 1). Of the various fungi occurring, only one species, Diplodia zeae, is recognized as a severe pathogen. The other fungus isolated, believed to have pathogenic tendency, is Nigrospora oryzae. No other severe pathogen known to occur on corn in other regions of the corn belt was isolated in the 3-year study. In most cases only one species grew from a kernel and dominated that isolate completely.

Through the technical assistance of Dr. C. T. Rogerson, mycologist of the Department of Botany and Plant Pathology, the following species of fungi were identified and recorded as present in the samples studied.

Fungi Isolated From Kansas Hybrid Seed Corn Produced 1952-54, Inclusive

Alternaria tenuis Nees ex Cda.
Aspergillus niger van Tieghem
A. clavatus Desm.
A. flavus Link ex Fr.
A. terreus Thom
A. carbonarius (Bain.) Thom
Chaetomium globosum Kze. ex Fr.
C. brasiliense Batista & Pontual
C. indicum Cda.
Diplodia zeae (Schw.) Lév.
Fusarium moniliforme Sheldon
F. equiseti (Cda.) Sacc.
F. oxysporum Schlecht.
F. poae (Pk.) Wr.
F. scirpi Lambotte & Fautr.
Nigrospora oryzae (Berk. & Br.) Petch
Penicillium frequentans Westling
P. funiculosum Thom
P. oxalicum Currie & Thom
P. notatum Westling
Rhizopus nigricans Ehr.
Trichoderma viride Pers. ex Fr.
(T. lignorum (Tode) Harz)

One isolate each of Streptomyces, Cephalosporium, Gonatobotrys, and Helminthosporium was obtained.

Table 1 gives the percentage of fungi and the counties from which the seed came.

Fusarium moniliforme[4] was isolated the greatest number of times of all of the fungi isolated during the 3 years. It remains the commonest of all species of fungi in Kansas seed corn. This was true in the studies made when open-pollinated seed was used. It was shown that an average of 93.8 percent of all ears tested and 94.0 percent of all kernels cultured were infected in the crops of 1920, 1921, and 1922 (1, 2). In 1924 investigations proved that 98 percent of all ears carried infection of F. moniliforme (2, 4). The hybrid seed corn in 1954 carried a high incidence of F. moniliforme in most counties (Table 1). In many of the samples, 100 percent of the seed showed the presence of this fungus to the exclusion of all others. Also, Table 1 shows that for the 3-year period 1952-54, 40 percent of all the kernels of white and yellow hybrids cultured contained F. moniliforme, which is less than half so much as occurred in the open-pollinated seed of 1920-1922, inclusive, during seasons of higher rainfall.

In an analysis of yellow and white samples for 2 years, it was found that in 1952 yellow corn had 23.1 percent F. moniliforme and white corn 26.5 percent, and in 1954 yellow corn had 75.6 percent and white corn 69.0 percent.

The only sample of hybrid seed corn tested in the 3 years from southwestern Kansas (Morton County) showed 16 percent of F. moniliforme and no other fungus organism. This may or may not be significant but at least it indicates that F. moniliforme flourished in this dry area of the State.

Diplodia zeae was present in small amounts but was obviously held in check by the lack of rainfall during the 3 years. It was somewhat more prevalent in the studies reported in 1921, 1922, and 1923 in open-pollinated corn. An average of 6.1 percent of all ears and 2.2 percent of all kernels were infected in the crops of 1921 and 1922. In 1923 samples of "good" seed ears from farmers were requested. Examination of these showed Diplodia zeae present in 9.2 percent of the ears and 2.3 percent of the kernels. It is believed random ear samples would have shown a higher percentage (2, 4). In the present studies it was found in 1952 that yellow corn had 1.4 percent D. zeae, while white samples had 2.5 percent, and in 1954 yellow corn had 0.9 percent and white samples showed 2.6 percent. The average percentage for the State, considering all the kernels cultured in the 3 years, was only 1.1. This is exceedingly small and indicates that loss in Kansas from D. zeae seedling blight was insignificant during these years.

Nigrospora oryzae was even less common than Diplodia zeae in the present study (Table 1). The average percentage for the 3 years was only 0.6.

These two organisms are the only ones regarded as pathogens among the fungi listed. It is recognized, however, that species of Aspergillus, Penicillium, and Rhizopus contribute to seed decay when environmental conditions are unfavorable for prompt seed corn germination.

Aspergillus niger in 1953 was the commonest of all the five species of Aspergillus listed.

Of the Penicillium species occurring, P. oxalicum was most common, while P. notatum occurred in two isolations. P. frequentans and P. funiculosum were each isolated once.

Rhizopus nigricans and variants were not so prevalent under the seed coat as the aforementioned organisms, but were prevalent on the surface of all seed corn.

[4] Imperfect stage of Gibberella fujikuroi (Saw.) Wr.

Table 1. Prevalence of fungi in Kansas hybrid seed corn, 1952-1954.

County and year	No. of kernels	Aspergillus spp.	Chaetomium spp.	Diplodia zeae	Fusarium moniliforme	Fusarium spp.	Nigrospora oryzae	Penicillium spp.	Rhizopus spp.	Trichoderma viride	Other fungi
		*Percentage of isolates									
Atchison											
1952	175	4.6	.6	1.1	21.1		2.9	2.9			
1953	575	6.0	.2	1.2	26.9	.7		1.8	1.4		
1954	325	1.5		1.5	79.1	.3	1.5		.9	.3	.3**
Brown											
1952	150	3.4		3.3	26.7	.7	1.3	10.7			.7***
1953	325	3.7	.6		7.7	.9		1.5	.9	.3	.6†
1954	400	2.0	.5		57.5		.8	2.0	.5	.3	
Clay											
1952	225	2.7		5.8	44.0		.9	3.1	2.7	.4	
1953	500	3.6	.2	1.2	40.8	1.4		1.0	.6		.2#
1954	275	2.6	.4	4.7	55.3	2.2		.4	.4		
Coffey											
1952	100	20.0##	1.0		26.0	2.0	2.0	2.0	4.0	3.0	
1953	25	4.0			8.0	4.0					
Doniphan											
1952	275	.7	.7		18.2		.4	3.3			
1953	100	1.0	1.0		23.0	1.0		1.0			
Franklin											
1954	75				21.3			1.3		2.7	
Jackson											
1952	50	4.0		6.0	26.0			8.0			
1953	225	7.2	.5	1.3	43.1	.9	.5	.9			
1954	325	.3	.3	2.5	72.6			.9	.3	.3	

Table 1. (Continued).

County and year	No. of kernels	Aspergillus spp.	Chaetomium spp.	Diplodia zeae	Fusarium moniliforme	Fusarium spp.	Nigrospora oryzae	Penicillium spp.	Rhizopus spp.	Trichoderma viride	Other fungi
Kingman											
1952	200	4.5		1.0	18.5	3.5	1.0	2.0			
Lyon											
1952	75			4.0	29.3		5.3				
1953	125	9.7			20.8				.9		
Morris											
1953	150	3.3		1.3	34.7	2.0				2.7	
Morton											
1953	25				16.0						
Nemaha											
1953	300	3.0	2.0	.7	21.0			.7			.3†
Osage											
1953	100	4.0		2.0	4.0	2.0					
1954	150			1.3	54.0			.7			
Pottawatomie											
1952	75	17.3			25.3	5.3	1.3	6.7		1.3	
1953	225	12.0	.8		28.4	.9		3.6	.4		.4†
1954	200				94.0			.5	.5		
Riley											
1953	525	5.0	.2		27.8	1.0		1.0	1.3	.2	
1954	575	3.1			87.1	.3		.3			.2+
Shawnee											
1953	50	8.0			22.0	4.0					
Smith											
1953	125	1.6			13.6		.8				

Table 1. (Continued).

County and year	No. of kernels	*Aspergillus* spp.	*Chaetomium* spp.	*Diplodia zeae*	*Fusarium moniliforme*	*Fusarium* spp.	*Nigrospora oryzae*	*Penicillium* spp.	*Rhizopus* spp.	*Trichoderma viride*	Other fungi
Unknown											
1952	150	.7	2.0		28.7	1.3	10.7	2.0			
1953	25	4.0			4.0						
Wabaunsee											
1953	100	10.0	4.0		13.0		1.0		1.0		
Woodson											
1953	125	6.4		3.2	26.4	3.2					
Total number											
Kernels	7425										
Isolates		297	29	82	2977	61	46	109	43	16	5
Percentage of isolates		4.0	0.4	1.1	40.1	0.8	0.6	1.5	0.6	0.2	0.1

*A blank appearing in the data for any year in which fungi were isolated means that the percentage was zero.
**Gonatobotrys sp.
***Phycomycete
/Alternaria tenuis
#Streptomyces sp.
+Helminthosporium rostratum.
##Two percent A. niger; 18% A. flavens.

Three species of Chaetomium were isolated; in order of prevalence they were C. globosum, C. indicum, and C. brasiliense. It should be noted that C. brasiliense is reported for the first time in Kansas. All of these species are regarded as saprophytic.

Fusarium spp. other than F. moniliforme included an occasional isolate of F. scirpi, F. equiseti, and F. poae. These are not regarded as pathogens.

Trichoderma viride was occasionally isolated in each of the three crop years. It is a saprophyte.

The white hybrid corn seed crop of 1952 showed a development which caused considerable inquiry and anxiety. Seed dealers, growers, and elevator operators in particular, sent in ears of white hybrid corn for examination, inquiring the cause of the pink tinge on the normally white chaff attached to the cob. The seed itself was bright, clean, plump, and showed no unusual disease symptoms, but apprehensive views were expressed. If the same cob discoloration was present on yellow hybrids, it could not be detected because of the natural reddish color of chaff and cob. Isolations were made from the white cob, the pink discolored chaff, and from kernels removed from pink areas. In every case cultures of Fusarium moniliforme were obtained. According to informed sources, many fields of white varieties had cobs showing more or less of this pink symptom. Previous investigations and observations by the writer have shown that Fusarium moniliforme occurring in Kansas corn does not cause appreciable injury (1, 2, 3, 4). The seed from these pink colored cobs showed good germination and vigor; therefore, those who inquired were advised that the seed should be acceptable and satisfactory for general planting.

In the fall of 1953 numerous inquiries were made about the prevalence of "smut" of selfed lines, on hybrid pop corn, and in fields of hybrid seed corn. Examination showed that the trouble was not corn smut but an unusual amount of Aspergillus niger infection and sporulation. Unquestionably some injury was caused to seed of selfed lines and of field and pop corn hybrids. The unusually dry season during the summer and fall perhaps made conditions favorable for this species. Apparently the developing kernels became infected, since isolations showed the presence of this fungus in considerable amounts in 1953.

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DEPARTMENT OF BOTANY AND PLANT PATHOLOGY, KANSAS AGRICULTURAL EXPERIMENT STATION, MANHATTAN

A PHYCOMYCETOUS MYCORRHIZA ON BARLEY ROOTS IN SOUTH DAKOTA

R. E. Ohms[1]

In connection with root rot studies on barley on three South Dakota soils in the greenhouse during the winter months of 1955-56, abundant phycomycetous mycorrhizal infection was found in roots of barley plants. The mycorrhiza was found on roots growing in soil from a field designated as a Pythium root rot nursery (1) located southwest of Colome, South Dakota. No infection of this type was observed on barley roots grown in soils collected from plots near Presho and Brookings, South Dakota. Direct examination of soil collected in the spring of 1956 from the Pythium root rot nursery produced approximately 100 phycomycetous mycorrhizal spores per cup of soil. These large spores appeared to be similar to if not the same as the A and B spores recently described by Gerdemann (2). No spores of these types were found in the Presho or Brookings' soils.

In addition to the A and B spores, C spores (2) were found on and connected to the same hyphae, about the barley roots grown in the greenhouse, as were the B spores. The B type spores varied in color from white to bright yellow, with approximately one-fourth of the spores being more uniform in size (220 microns in diameter) and shades of pink in color. The hyphae about the roots of naturally infected barley had the wound healing reaction observed and described by Gerdemann (3) when hyphae were grown in water culture or near artificially inoculated roots.

This fungus isolated from barley in South Dakota appears to be the same type of phycomycetous mycorrhizal fungus isolated from red clover and strawberry roots in Illinois (2).

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DEPARTMENT OF PLANT PATHOLOGY, SOUTH DAKOTA STATE COLLEGE EXPERIMENT STATION, BROOKINGS, SOUTH DAKOTA

[1] Assistant Plant Pathologist, Department of Plant Pathology, South Dakota State College, Brookings, South Dakota.

DWARF BUNT ON RYEGRASS IN NEW YORK

Wade G. Dewey and L. J. Tyler

Dwarf bunt, caused by Tilletia brevifaciens George W. Fischer (T. controversa Kuehn), was observed in 1955 on perennial ryegrass (Lolium perenne L.) and on Italian ryegrass (L. multiflorum Lam.). This appears to be the first published record of the dwarf bunt fungus on Lolium species. The diseased volunteer ryegrass plants were growing among winter wheat plants in an experimental field nursery maintained for studies of dwarf bunt. Inoculation and infection of the ryegrass plants apparently resulted from soil-borne inoculum of the dwarf bunt fungus that had been used to inoculate wheat in the nursery.

Diseased ryegrass culms were dwarfed, attaining 1/4 to 1/3 the height of healthy culms. Diseased spikelets were compressed and the glumes were expanded; small, somewhat indurate, dark colored sori replaced the seed. Spores taken from sori developed on the ryegrasses were morphologically indistinguishable from those on wheat affected by dwarf bunt. Average diameters of spores from wheat, perennial ryegrass, and Italian ryegrass were 21.0, 20.4, and 21.0 microns, respectively. Reticular structures on the spores, sheaths encasing the spores, and hyaline cells of the fungi from ryegrass appeared to be identical with those of the dwarf bunt fungus from wheat.

Cross inoculations of wheat and the two ryegrasses with the three fungous isolates have not been performed.

Diseased specimens of the two ryegrass species were placed in the Plant Pathology Herbarium of Cornell University under accession numbers 43893 and 43894.

DEPARTMENTS OF PLANT BREEDING AND PLANT PATHOLOGY, CORNELL UNIVERSITY, ITHACA, NEW YORK

A PHYSALOSPORA DISEASE OF LAWN GRASS

R. L. Self[1] and C. H. Driver[2]

St. Augustine lawn grass (Stenotaphrum secundatum) was observed in July, 1955, to be dying in large areas of well established lawns in the Spring Hill residential area of Mobile, Alabama. Superficially the symptoms of this disease resembled the brown patch disease of turf grasses. The leaf blades, however, showed numerous dark perithecia embedded in the tissue (Figure 1). The leaf blades died from the leaf callus region (where the blade joins the sheath) toward the tip of the blade. This seemed to indicate that the initial infection occurred in the cavity where the leaf callus surrounds the stem. The callus area of the leaf was the first to disintegrate, causing the leaf blades to fall from the stem. Bare stem runners in severely infected areas of lawns were one of the characteristic symptoms of the disease.

A fungus was consistently isolated in pure culture when the infected tissue was washed in running tap water for 1 hour and plated on water agar. The fungus produced a perfect stage, but no imperfect stage, when grown on oatmeal agar at 23° C for 14 days.

The fungus was tentatively identified as a species of Physalospora. The perithecia found in infected tissue were erumpent, spherical in shape, dark brown in color, distinctly ostiolate, and averaged 102 microns in diameter. The ascospores, both in nature and in pure culture, were hyaline, slightly curved, and averaged 13.5 x 4.0 microns in size.

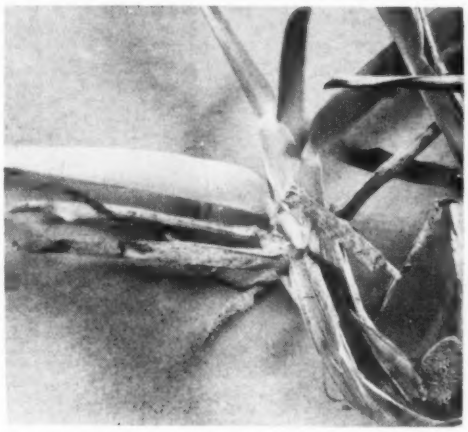

FIGURE 1.
Disease symptoms caused by Physalospora on St. Augustine grass.

Cultures of this fungus used in preliminary inoculation experiments produced the symptoms of the disease on St. Augustine grass. The taxonomy, pathogenesis, and control of this organism will be studied more extensively.

ORNAMENTAL HORTICULTURE FIELD STATION, AGRICULTURAL EXPERIMENT STATION OF THE ALABAMA POLYTECHNIC INSTITUTE, SPRING HILL, AND RESEARCH DEPARTMENT, INTERNATIONAL PAPER COMPANY, MOBILE, ALABAMA.

[1] Plant Pathologist in Charge, Ornamental Horticulture Field Station, Agricultural Experiment Station of the Alabama Polytechnic Institute, Spring Hill, Alabama.

[2] Research Botanist, International Paper Company, Mobile, Alabama.

THE UNUSUAL OCCURRENCE OF THREE LEAF-SPOTTING FUNGI ON GRASSES IN NOVA SCOTIA[1]

D. W. Creelman[2]

Three fungi, new to the Province, caused considerable damage to three grass crops in Nova Scotia in 1955. There were marked similarities in the three outbreaks. Each fungus produced an eyespot symptom on its host; each outbreak was confined to a single field; and each resulted in a marked reduction in the yield of high quality fodder. The fungi concerned were Heterosporium phlei Gregory on timothy (Phleum pratense L.); Mastigosporium album Riess on meadow foxtail (Alopecurus pratensis L.); and Mastigosporium rubricosum (Dearn. & Barth.) Nannf. on orchard grass (Dactylis glomerata L.).

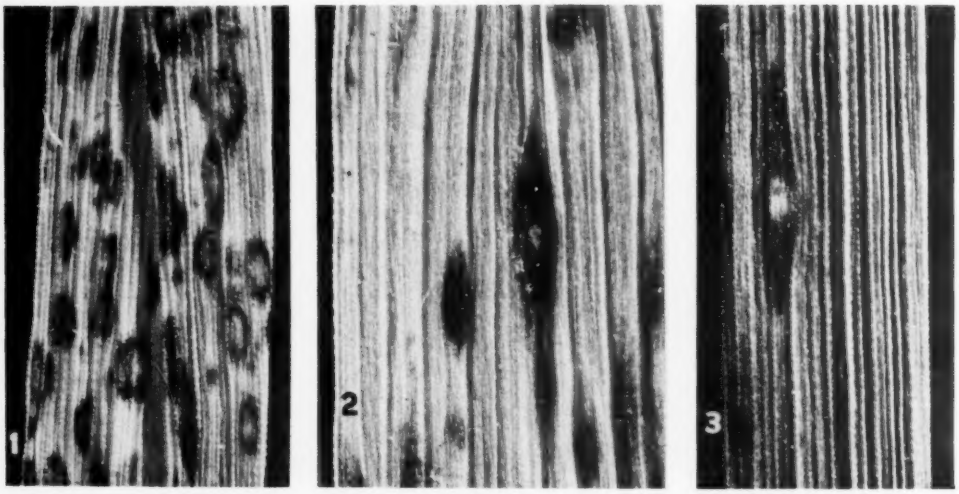

FIGURE 1. Heterosporium phlei on timothy.
FIGURE 2. Mastigosporium album on meadow foxtail.
FIGURE 3. Mastigosporium rubricosum on orchard grass.

Heterosporium phlei on Timothy

The fungus that causes the disease variously named Heterosporium leaf spot by Gregory (2) and Horsfall (3), and eyespot by Sprague (8) has been previously reported from all Canadian Provinces with the exception of Nova Scotia and Newfoundland (4, 1). It is also widely distributed in the United States (8).

Its presence in Nova Scotia was recorded for the first time in July 1955 at East Mines, Colchester County. Infection was limited to a single field and was severe in intensity. All leaves of all plants examined were affected, and as many as 30 lesions occurred in a linear centimeter of leaf surface. The apical one-third to one-half of each leaf was dead, resulting in a scorched appearance of the affected field.

The lesions were characteristic of the disease as described by Gregory (2), Horsfall (3), and Sprague (8), (Fig. 1). Sporulation by the fungus was almost entirely absent in the lesions, but was abundant on both surfaces of the dead apical portions of the leaves.

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[1] Contribution No. 1530 from the Botany and Plant Pathology Division, Science Service, Canada Department of Agriculture, Ottawa, Ontario.

[2] Assistant Plant Pathologist.

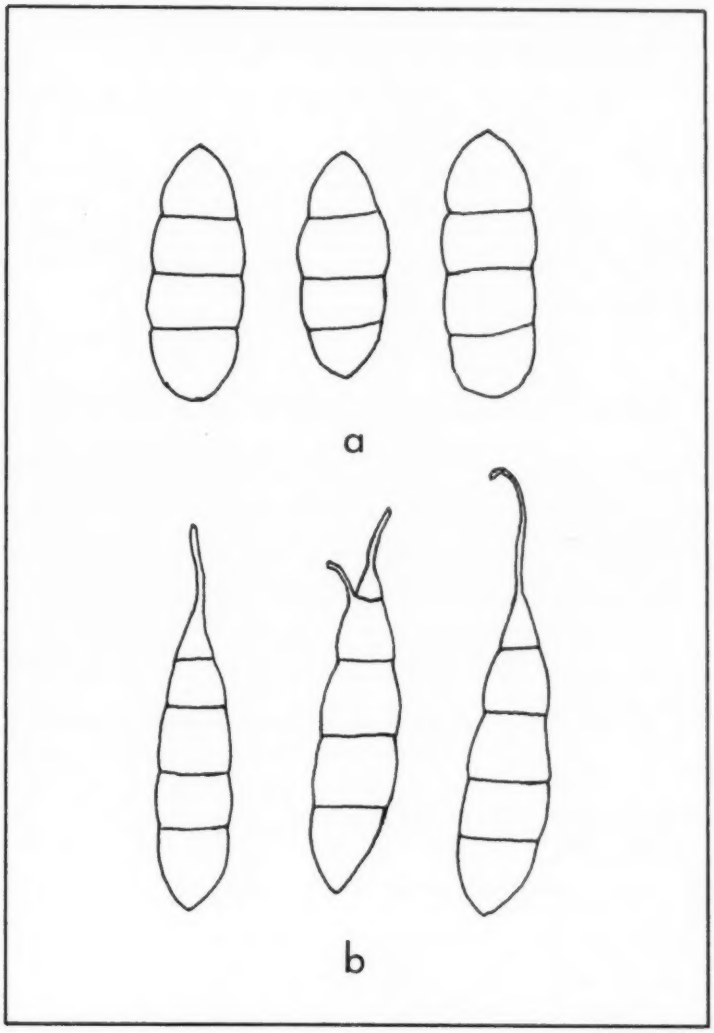

FIGURE 4. Outline drawings of Mastigosporium conidia, x about 1050:
a -- M. rubricosum.
b -- M. album.

Mastigosporium album on Meadow Foxtail

The fungus Mastigosporium album has been reported as the cause of leaf fleck on meadow foxtail and other grasses in Britain and on the Continent (7). Reports of its presence in North America are rare and of recent occurrence. So far as can be determined, M. album was first discovered in North America on Alopecurus pratensis at Wolfville, Nova Scotia in July, 1953 (5). In June of the following year Ross (6) observed it in New York State. The disease has recurred annually since 1953 on Alopecurus in the same field at Wolfville, and has shown no tendency to spread to nearby fields or to other grass species in the same field.

The lesions on meadow foxtail are numerous, elongate, 1-2 mm in length and 0.5-1 mm in width. They are purplish brown in color and are frequently surrounded by a narrow chlorotic zone. The spores of the fungus appear as glistening white flecks at or near the center of the lesion (Fig. 2). Sporulation is mainly epiphyllous but may be hypophyllous as well. Heavily infected leaves are eventually killed and defoliation occurs.

The conidia are elliptical, mostly 4-septate, and bear characteristic filiform, nonseptate appendages on the terminal and occasionally on the penultimate cell (Fig. 4b).

Mastigosporium rubricosum on Orchard Grass

This fungus, causing eyespot of orchard grass, is reported by Sprague (8) to be common in Europe and in the humid parts of Oregon, Washington and British Columbia. He shows that its distribution on this and other grasses is largely confined to the Pacific Coast and Rocky Mountain States and Canadian Provinces.

M. rubricosum was discovered on orchard grass at Mavailette, Digby County in August, 1955. This appears to be the first record of its occurrence in eastern North America.

The lesions on orchard grass are numerous, elongate, mostly vein restricted, 1-6 mm in length and 1-2 mm in width. The spots are purple to brown in color with gray to fawn centers (Fig. 3). The chlorotic zone which frequently surrounds the lesions of M. album on meadow foxtail is not present in this disease. At Mavailette in 1955 the disease was of sufficient intensity to cause heavy defoliation.

The conidia are 2-3 septate and lack the characteristic appendages of M. album (Fig. 4a).

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PLANT PATHOLOGY LABORATORY, KENTVILLE, NOVA SCOTIA

REACTION OF WINTER WHEAT VARIETIES AND TRITICUM X AGROPYRON HYBRIDS WHEN INOCULATED WITH STREAK MOSAIC VIRUS BY THE MITE VECTOR ACERIA TULIPAE KEIFER[1]

J. E. Andrews[2] and J. T. Slykhuis[3]

Abstract

Reactions of 1124 common wheat accessions and of 41 selections from crosses between Triticum and Agropyron, when inoculated with streak mosaic virus by the mite Aceria tulipae Keifer, were studied in the greenhouse. All of the common wheats were found to be susceptible. Sixteen of the Triticum x Agropyron lines were found to be resistant and 5 to be symptomless carriers of the virus. Mites failed to survive or reproduce normally on most but not all of the resistant lines.

Reactions of some wheat varieties and Agrotricum hybrids to wheat streak mosaic have been reported (1, 2,3). In these studies the material was inoculated by the wiping method. Slykhuis (4) found that the eriophyid mite Aceria tulipae Keifer, which is a vector of the wheat streak mosaic virus Marmor virgatum McK., also often carries an additional component that causes severe chlorosis, necrosis and stunting of wheat. This latter component is not transmitted manually. Therefore, reactions of varieties, when inoculated manually, may differ from those obtained where the vector is involved. Resistance to the vector also may provide effective resistance to the disease. This is a report of studies of reaction to the streak mosaic virus of certain wheat accessions and selections from Triticum x Agropyron when inoculated by means of the mite vector.

Material and Methods

The inoculum of wheat streak mosaic and the population of Aceria tulipae used as vectors were obtained from infected wheat plants from fields in southern Alberta. Infected plants were brought into the greenhouse and both the inoculum and vector population were increased on Kharkov 22 M.C. winter wheat grown in pots.

The material under test was inoculated by mite transmission. Plants were grown on greenhouse benches in 6-inch pots or 8-inch crocks with 15 seedlings in each. After the seedlings had emerged, pots of Kharkov 22 M.C. wheat infested with mites and infected with streak mosaic were placed at the ends at intervals along the greenhouse benches. Ten-inch electric fans were placed behind the source plants at the ends of the benches and were operated at alternate ends of the benches on alternate days. This was continued during the daylight hours for 2 weeks. Reactions were determined about 4 weeks after inoculation when all check pots showed symptoms of the disease. In the case of plants failing to show definite symptoms, tests for the presence of the disease were made by manually inoculating Kharkov 22 M.C. wheat using juice of the plants in question as inoculum. In addition, some of the material was tested by manual inoculation as well as by mite transmission.

The variety Kharkov 22 M.C. occupies most of the winter wheat acreage in Alberta and may be severely damaged by streak mosaic in the field. It was included at intervals of every tenth pot throughout the material under test as a check on both the effectiveness of the inoculation method and the reactions of varieties. Any accessions showing symptoms of streak mosaic and mite infestations as severe or more severe than the check were considered to be of no particular value as sources of resistance.

The material tested included 1124 wheat accessions, the majority of which were obtained from the world collection of wheats of the United States Department of Agriculture. Others were obtained directly from various countries. The countries of origin with numbers of varieties tested from each are as follows:

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[1] Joint contribution of the Cereal Crops Division, Experimental Farms Service--Contribution No. 206, and the Botany and Plant Pathology Division, Science Service--Contribution No. 1531, Canada Department of Agriculture, Ottawa, Ontario.

[2] Cerealist, Cereal Crops Section.

[3] Plant Pathologist, Botany and Plant Pathology Section.

Table 1. Classification of selections from Triticum x Agropyron crosses for reaction to wheat streak mosaic, chlorotic spotting, and mites.

Class	Lethbridge T-A No.	Hybrid	Source*
Resistant to streak mosaic, no spotting, no mites found.	1	Wheat x A. elongatum	1
	34	T. dicoccum x A. intermedium	3
	40	Kharkov x A. intermedium	3
	56	Wheat x A. elongatum	4
Resistant to streak mosaic, no spotting, a few mites found.	48	Kharkov x A. intermedium	3
	51	(Wheat-rye x A. elongatum) x Cheyenne	4
Resistant to streak mosaic, with spotting, no mites found.	26	T. vulgare x A. intermedium	3
	30	Kharkov x A. elongatum	3
	32	do	3
	35	T. dicoccum x A. intermedium	3
	36	do	3
	37	T. turgidum x A. intermedium	3
	39	Kharkov x A. intermedium	3
	54	Wheat x A. elongatum	4
Resistant to streak mosaic, with spotting, a few mites found.	31	Kharkov x A. elongatum	3
	41	Mindum[2] x A. elongatum	3
Symptomless carrier of streak mosaic virus, spotting present, no mites found.	5	Chinese[2] x A. elongatum	2
Symptomless carriers of streak mosaic virus, spotting present, a few mites found.	6	Chinese[2] x A. elongatum	2
	10	do	2
	29	Kharkov x A. elongatum	3
	33	do	3

Table 1. (cont'd)

Class	Lethbridge T-A No.	Hybrid	Source*
Segregating for streak	7	Chinese x A. elongatum	2
mosaic reaction with vary-	9	do	2
ing degrees of spotting	11	do	2
and mite infestation.	25	Dawson's Golden Chaff[2] x A. elongatum	3
	27	Minturki[2] x A. elongatum	3
	42	Minturki[2] x A. intermedium	3
	43	Chinese x A. elongatum x Kharkov	3
	44	Chinese x A. elongatum x Yaroslav	3
	46	Kharkov x A. elongatum	3
	52	Wheat[3] x A. elongatum	4
	53	Wheat x A. elongatum	4
Susceptible to streak	55	Wheat x A. elongatum	4
mosaic with moderate	57	do	4
spotting and moderate	58	(Wheat-rye x A. elongatum) x Cheyenne	4
mite infestation.	59	Wheat x A. elongatum	4
	60	do	4
	61	[(Mindum x A. trichophorum) x (Med.-Hope x Pawnee)] x (Nebred x Ceres-H44)	4
	62	[(Mindum x A. trichophorum) x Red Chief] x (Med.-Hope x Pawnee)	4
	63	Wheat x A. elongatum	4
	64	[(Chinese-rye x Chinese) x A. elongatum] x Forward	4

*Source

1. Dr. W. J. White, Forage Crops Laboratory, Saskatoon, Sask.
2. Prof. L. H. J. Shebeski, University of Manitoba, Winnipeg, Man.
3. Dr. T. M. Stevenson, Forage Crops Division, Central Experimental Farm, Ottawa, Ontario.
4. Dr. J. W. Schmidt, Agronomy Department, Kansas State College, Manhattan, Kans.

Africa (2), Argentina (12), Armenia (7), Australia (15), Afghanistan (7), Canada (27), China (101), Caucasus (13), England (17), France (49), Greece (2), Germany (4), Hungary (2), Holland (7), Iran (4), Italy (6), India (8), Japan (10), Manchuria (1), Mexico (1), Norway (2), Persia (1), Portugal (2), Roumania (6), Scotland (1), Spain (6), Sweden (12), Turkestan (2), Transcaucasia (7), Turkey (2), U.S.A. (605), and U.S.S.R. (158).

Forty-one selections from crosses between Triticum and Agropyron also were tested by both mite transmission and manual inoculation. The sources of this material are given in Table 1.

Results

Most of the common wheat accessions developed more severe symptoms of wheat streak mosaic than did the check variety Kharkov 22 M.C. None demonstrated enough resistance to warrant further consideration with respect to this disease.

The selections from the Triticum x Agropyron crosses differed considerably in symptoms of streak mosaic and chlorotic spotting, and in degree of mite infestation (Table 1). Similar reactions to streak mosaic were obtained from both manual and mite inoculations. The lines were classified as resistant, susceptible, segregating, or symptomless carriers. The last group showed no symptoms of streak mosaic but the presence of the virus was detected by using their juice for manual inoculation of healthy plants.

The chlorotic spotting observed was caused by the feeding of mites, by a virus transmitted by the mites but not by manual means (4), by local reaction to the wheat streak mosaic virus, or by any combination of these. Spotting was most severe on lines classed as susceptible to streak mosaic. It was present on all lines classed as symptomless carriers and on some, but not all, of the resistant lines. It occurred on only a few of the hybrids inoculated by the manual method and a further check indicated that in these instances the spotting was a local lesion type of symptom caused by the streak mosaic virus.

Populations of mites four weeks after infestation were largest on the susceptible lines. No mites were found on some of the resistant lines and on some of the symptomless carriers. The mites apparently failed to survive or reproduce normally on these lines. The use of such material in the field may provide a control for the disease by reducing the population of its mite vector.

Sixteen lines were found to be resistant to streak mosaic (Table 1). Four of these also showed no evidence of spotting or mite survival.

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CANADA DEPARTMENT OF AGRICULTURE, LETHBRIDGE, ALBERTA

INFLUENCE OF WHEAT STREAK MOSAIC ON WINTER WHEAT IN AN AREA OF MONTANA IN 1955[1]

F. H. McNeal and A. L. Dubbs[2]

SUMMARY

Eleven winter wheat fields in the Judith Basin of Montana were studied in 1955 to determine the effect of wheat streak mosaic on yield and other plant characters.

Wheat streak mosaic caused losses in yield, kernel weight, and bundle weight. Losses were also evident for test weight, plant height, and the number of kernels produced on each head.

Number of culms produced was the only character studied that was not materially influenced by wheat streak mosaic. Highly significant negative correlation coefficients were obtained between all characters studied and percentage wheat streak mosaic, except number of culms.

It is suggested that cultural practices, and perhaps seeding dates, will be of extreme importance in preventing spread of the disease until such time as resistant varieties are available.

Some winter wheat fields in the Judith Basin of Montana showed a heavy incidence of wheat streak mosaic in 1955. The symptoms and the manner of spread of wheat streak mosaic have been described by Slykhuis (1, 2). This disease was positively identified for the first time in Montana in 1953[3].

Certain areas in the Judith Basin of Montana had heavy hail losses at harvest in 1954. This was followed by rain which helped to sprout the fallen grain. The new plants thus produced provided ideal conditions for over-wintering of wheat streak mosaic. Many winter wheat fields seeded adjacent to these hail-shattered fields were infected by the virus in the fall of 1954. Mites (Aceria tulipae Keifer) were found on all diseased plants examined.

Losses from wheat streak mosaic to some growers in the Judith Basin area in 1955 are reported here.

MATERIALS AND METHODS

Eleven winter wheat fields in an area 3 by 4 miles in the Judith Basin of Montana were sampled in the fall of 1955. Samples were taken by pulling 16 square feet of row from five random locations in each field. Six of the fields were infected and the other five chosen were disease-free.

The percentage of plants with mosaic was estimated for each area of the field from which a sample was taken. All other data were obtained from the harvested samples.

Roots were cut from each sample and an average plant height was obtained. Total bundle weight in grams and the number of culms producing heads were determined. Fifty heads taken in consecutive order from each sample were threshed to obtain the average number of kernels per head. Kernel weight was determined by weighing 1,000 kernels from each sample. Bushels per acre were obtained for each sample by weighing the grain in grams and multiplying by the factor of 0.1. There was insufficient grain for a test weight on each sample, so the five samples were bulked and one test weight value was taken for each field. All data presented are an average of the five samples, with the exception of test weight.

The fields and pertinent information obtained from the grower on each are included in Table 1.

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[1] Joint Contribution of the United States Department of Agriculture and the Montana Agricultural Experiment Station, Paper No. 374 Journal Series.

[2] Agronomist, Field Crops Research Branch, Agricultural Research Service, United States Department of Agriculture, and Assistant in Agronomy, Montana Agricultural Experiment Station, respectively. The authors express appreciation to J. L. Krall, Superintendent of the Central Montana Branch Station, for assistance in collecting the samples. Statistical work was done by the Montana State College Statistical Laboratory.

[3] Letter from H. H. McKinney to R. F. Eslick dated July 22, 1953.

Table 1. Eleven winter wheat fields and information obtained from the grower on each in 1955.

Key	Field	Winter Wheat Variety	Planting Date 1954	Field Size Acres	Seeding Rate Lbs/Acre	Fallow Treatment 1954
A	Gipe	Karmont	Sept. 10	40	60	Clean
B	Kaufman #2	Mixture*	Sept. 9	40	60	Clean
C	Heinrick #2	Yogo	Sept. 6	80	60	Clean
D	Heinrick #1	Yogo	Sept. 5	104	60	Clean
E	Kaufman #1	Yogo	Sept. 10	106	60	Clean
F	Kaufman #3	Mixture*	Sept. 10	106	60	Stubble Mulch
G	Kaufman #4	Mixture*	Sept. 7	80	60	Clean
H	Heintz	Yogo	Sept. 7	8	60	Clean
I	Combellick	Yogo	Sept. 5	80	55	Stubble Mulch
J	Vestal	Yogo	Sept. 10	19	55	Stubble Mulch
K	Watson	Yogo	Sept. 10	30	60	Clean

* Yogo, Karmont and Newturk.

Table 2. Agronomic data from 11 winter wheat fields in 1955, determined on five random samples from each field.

Field	Wheat Streak Mosaic %	Plant Ht. In.	Culms Per Sample No.	Bundle Wt. Gms.	Kernels Per Head No.	Kernel Weight (1,000) Gms.	Test Wt. Lbs.	Bu. Per Acre
A	0.0	36.2	607	912	20.5	29.91	61.2	33.9
B	0.0	36.8	674	991	20.4	28.26	60.6	31.4
C	35.0	37.2	814	1202	22.0	21.26	56.5	29.5
D	28.0	30.6	693	754	18.3	21.36	57.2	22.2
E	0.0	33.6	560	714	19.1	23.18	60.2	19.9
F	35.0	33.8	427	619	21.2	24.64	58.3	19.6
G	0.0	36.2	435	620	22.6	21.57	57.1	18.3
H	0.0	30.2	387	504	22.2	26.36	59.3	17.6
I	76.0	25.2	515	562	15.9	21.09	57.0	15.2
J	74.0	24.6	385	477	22.2	17.74	52.6	12.2
K	84.0	28.6	403	467	17.8	22.60	56.4	11.7

Table 3. Regression equations and percentage reduction in different plant characters when affected by 30, 50, and 70 percent of wheat streak mosaic.

Character	Regression Equation	Percent Reduction At Different Percentage Levels of Mosaic 30	50	70
Bushels per acre	$\hat{Y} = 24.9829 - 0.1307X$	15.7	26.2	36.6
Bundle weight (gms.)	$\hat{Y} = 800.4320 - 2.9607X$	11.1	18.5	25.9
Culms per sample	$\hat{Y} = 565.2827 - 0.9672X$	5.1	8.6	12.0
Kernel weight (gms.)	$\hat{Y} = 25.2093 - 0.0582X$	6.9	11.5	16.2
Kernels per head	$\hat{Y} = 21.1441 - 0.0314X$	4.5	7.4	10.4
Plant height (inches)	$\hat{Y} = 35.1181 - 0.1003X$	8.6	14.3	20.0

EXPERIMENTAL RESULTS

Information from the samples collected in 11 winter wheat fields is included in Table 2. The analysis of variance method was used to test for differences in kernel weight, bundle weight, percent mosaic, and bushels per acre. Significant F values were obtained in each analysis for the main effects. Differences were found between disease-free as well as diseased fields. However, this is to be expected since it is well known that soil variation and differences in tillage operations may cause extreme variation in productiveness from farm to farm.

There was a rapid decrease in yield as the percentage of wheat streak mosaic increased. This decrease in yield was accompanied by some decrease in bundle weight and kernel weight.

Some differences appear to exist for plant height, kernels per head, and test weight. Little difference was noted in the number of culms in each sample.

The percentage of wheat streak mosaic was negatively correlated with bushels per acre, weight of 1,000 kernels, kernels per head, bundle weight, plant height, and culms per sample. All r values were highly significant except that for number of culms.

The regression equation for six characters on percent mosaic is shown in Table 3. The F value for regression was highly significant for each, except number of culms.

Percentage reduction in performance of each of the six characters was predicted at three levels of mosaic (Table 3). The largest percentage loss is in yield. It is of interest to note that the percentage loss in yield is nearly equal to the combined losses from culms, kernel weight, and kernels per head.

DISCUSSION

From observations of diseased wheat fields in various sections of Montana in 1954 and 1955 it was obvious that losses in production would occur. In this study, an attempt was made to measure the loss that can occur as a result of this disease.

Wheat streak mosaic virus is not transmitted through the seed, so proper cultural methods are the only known means of control at present. Seeding of winter wheat prior to September 10 is being discouraged in Montana. However, delayed seeding may not be sufficient to prevent the disease, as indicated by seeding dates in Table 1. Clean fallow and the destruction of infected volunteer plants prior to seeding may be more important.

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UNITED STATES DEPARTMENT OF AGRICULTURE AND MONTANA AGRICULTURAL EXPERIMENTAL STATION

INTERFERENCE AND SYNERGISTIC REACTIONS WITH RESPECT TO BARLEY STRIPE-MOSAIC VIRUS AND BROME MOSAIC VIRUS

H. H. McKinney[1]

Interference Among Strains of the Barley Stripe-Mosaic Virus: Greenhouse tests with dual infections by avirulent and virulent strains of the barley stripe-mosaic virus (6, 7, 8) in wheat and barley, have shown a much lower degree of interference than that obtaining in dual infections with the wild or field strain of tobacco mosaic virus and some of its yellow mosaic mutants (4, 5). Because of the apparently low degree of interfence between strains of the barley stripe-mosaic virus, the isolation of strains from mixtures has been more difficult than was the case with the tobacco mosaic strains (5). The occasional strongly chlorotic leaf markings which sometimes appear in plants infected with avirulent strains may represent mutations or they may be ordinary admixtures. The semivirulent isolates require further study before it will be known if they represent mechanical blends of virulent and avirulent strains.

As in the early work with viruses in tobacco (1, 2, 4, 5), and to a limited extent in wheat (3), the use of the dilution-inoculation method, and the selection of distinctive symptom types among the infected plants, as well as in localized leaf areas, facilitate the segregation of strains. Furthermore, some natural segregation of virus strains occurs among the infected seeds produced by a diseased plant, and this aids in the work of isolation.

Tests have shown conclusively that, once systemic infection is established by an avirulent strain, further infection by the virulent strain used is blocked (Fig. 1). Such blocking or protecting by the avirulent strain is just as effective as that of the field strain of the tobacco mosaic virus, against its yellow mosaic mutants. At temperatures of 75° F and above, a period of 7 days after the first signs of infection by the avirulent strain has been found ample to obtain effective blocking or protection against the virulent strain used, in all tests of the wheats and barleys listed below.

Spring wheat:	Converse, C.I. 4141; Marquis, C.I. 3641; Rescue, C.I. 12435; Rushmore, C.I. 2803; Saunders, C.I. 12567; Thatcher, C.I. 1003
Winter wheat:	Michigan Amber, C.I. 11770
Spring barley:	Alli, C.I. 6251; Atsel, C.I. 6250
Winter barley:	Wintex, C.I. 6127

In the indexing of seed for the presence or absence of avirulent strains, the blocking test is used to assist in the selection of virus-free plants for propagation. After removing all the seedlings that express signs of infection, the apparently healthy seedlings are space-planted to prevent inter-plant contact (8). These selected plants are then tested for latent virus by inoculating the juice from leaf samples into Atsel barley, Rescue wheat, or other suitable indicator plants. If no signs of infection appear in any of the indicator plants inoculated from a given plant selection, all of the indicator plants are reinoculated with the virulent strain of virus about 10 days after the first inoculation. When all the indicator plants develop symptoms of the virulent strain, the selected plant is regarded as being probably free of latent virus. The selected plants can be sampled and tested several times, and the indicator plants can be inoculated with the virulent strain at least twice to detect possible escapes. In highly resistant lines, thorough sampling of the selected plants will be important, as virus may not be uniformly present in all of the leaves.

Synergistic Reactions in Dual Infections With the Viruses of Barley Stripe-Mosaic and Brome Mosaic: Dual infections with brome mosaic virus (7) and the barley stripe-mosaic virus induce striking synergistic reactions in the barley and wheat varieties tested. The accentuated stunting in Atsel barley, illustrated in Figure 2, is typical of dual infections involving an avirulent strain of the barley stripe-mosaic virus. The accentuation of leaf markings in the chronic phase with the same dual infection in Concho winter wheat is illustrated in Figure 3.

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[1] Plant Pathologist, Field Crops Research Branch, Agricultural Research Service, Department of Agriculture. Acknowledgment is due Henry J. Breen and Lester W. Greeley for assistance in conducting these studies.

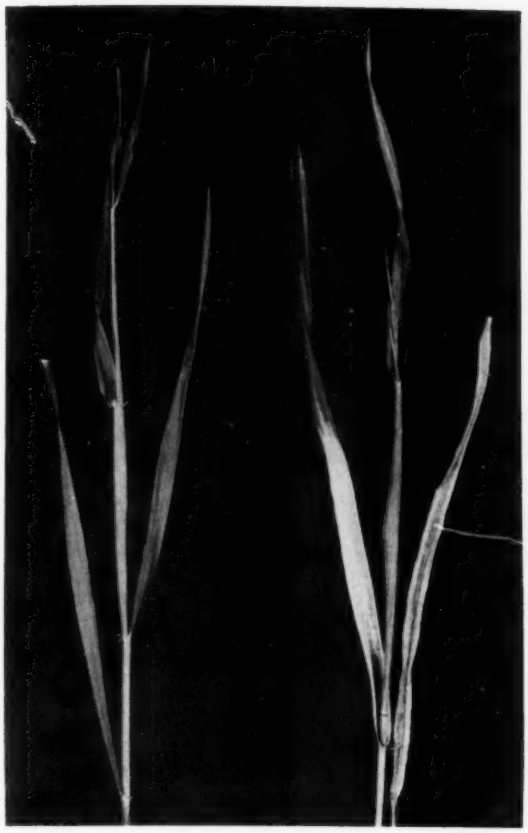

FIGURE 1. Shoots of Atsel barley plants. Shoot at left shows the blocking or protecting effect of an avirulent strain of the barley stripe-mosaic virus. This shoot is from a plant infected with the avirulent strain before it was re-inoculated with the virulent strain. The shoot on the right is from a plant that was healthy at the time it was inoculated with the virulent of virus.

Similar results with respect to stunting of the plants, and to accentuated leaf markings, have been obtained in Kiowa and Stafford winter wheats, and in Pilot and Rushmore spring wheats, An increase in the number of side-shoots usually occurs.

With winter varieties, accentuated leaf markings caused by dual infections are evident all through the chronic phase, but accentuated stunting is not evident until after the end of the tillering period when the stems have started to elongate. When dual infections involve the virulent strains of the barley stripe-mosaic virus, the plants develop extreme stunting, and frequently are killed.

In Atsel barley, the accentuation of the stunting and of the leaf markings occurs either when the virus extracts are mixed in equal parts and introduced into the plants simultaneously or when the second virus is introduced soon after signs from the first inoculation appear. With other varieties of barley and wheats tested, the barley stripe-mosaic virus was introduced first.

Since the brome mosaic virus is not known to be transmitted through the seed, it appears that it may be used as an aid in selecting virus-free plants from lots of seed in which the seed-borne barley stripe-mosaic virus is present. With varieties tested thus far, only slight stunting occurs, and the leaf markings are very mild in the chronic phase, when virus-free plants are incoulated with the brome mosaic virus. The data available indicate that the yield of seed from such plants is reduced from 11 percent to 53 percent. While this is a considerable reduction in the amount of seed, this synergy test eliminates plants with the seedborne virus with less work than is required to make the blocking or protection test described above.

Like the blocking test, the synergy test should be used with some caution until more information has been obtained. In testing for possible seed transmission of the brome mosaic virus, it must be kept in mind that the leaf markings frequently are absent in the chronic phase

FIGURE 2. Atsel barley plants showing synergistic reaction. Pot 1, virus-free control; pot 2, infected with an avirulent strain of the barley stripe-mosaic virus; pot 3, infected with the brome mosaic virus; pot 4, dual infection with both viruses.

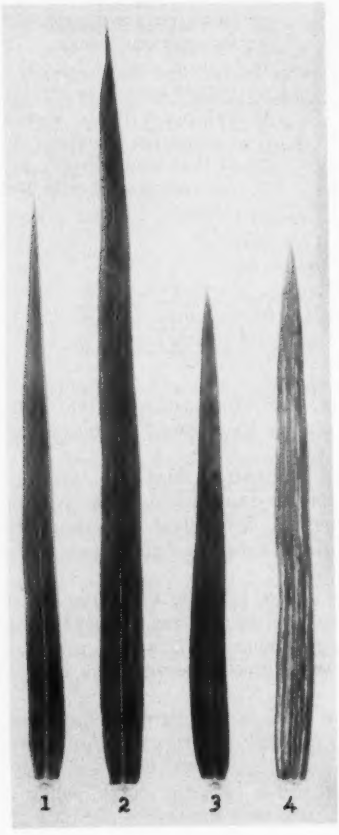

FIGURE 3. Concho winter wheat flag leaves showing synergistic reaction. Leaf 1, virus-free control; leaf 2, infected with avirulent strain of the barley stripe-mosaic virus; leaf 3, infected with the brome mosaic virus; leaf 4, dual infection with both viruses.

of plants infected with this virus, and that any infection from seed is likely to be evidenced by exceedingly mild signs or to be masked in the seedlings and plants. Inoculation transfers should be made to a suitable suscept such as Golden Giant sweet corn (7), in order to verify the presence or absence of virus, or the synergy test may be applied directly to the suspected plants by inoculating them with a suitable strain of the barley stripe-mosaic virus.

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FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE, BELTSVILLE, MARYLAND

A VIRUS FROM ORCHARD GRASS THAT INFECTS OATS

H. H. McKinney[1, 2]

Orchard grass (Dactylis glomerata L.) plants with mosaic symptoms, collected October 18, 1949 by A. G. Johnson on the farm of W. J. Dietrich, Wallingford, Massachusetts, were brought to the writer for study. Owing to difficulties with the virus and to the pressure of other problems, this study advanced slowly, and still is far from complete. However, because of interest in the blue dwarf disease of oats (4), and since the orchard grass virus induces a blue dwarf in Letoria oats, it seems advisable to report the results of the studies now.

INOCULATION TESTS

The virus transmits with difficulty by the carborundum-leaf-wiping method. Of the 301 orchard grass seedlings inoculated, 160 (about 53 percent) became infected. In 29 separate tests, all of the plants became infected in 6 tests, and there was no sign of infection in one. The period from inoculation to the expression of symptoms ranged from 2 to 8 weeks. It appears that inoculum should be prepared from young plants in order to obtain high percentages of infection. Symptoms are expressed over a wide range of temperatures and light conditions, but in greenhouse culture autumn and spring conditions seem to be more favorable than those in the summer.

In orchard grass, there is a rather wide variation in the symptoms among the individual plants, and some show leaf markings resembling those of cocksfoot (Dactylis glomerata) streak which occurs in England, and which was reported and illustrated by Smith (6) and illustrated by Peto (5). At the beginning of the study it was suspected that several strains of the virus accounted for the different symptom types, but tests indicate that genetic variability in the host is the chief cause.

HOST RANGE

Limited tests show that the virus infects some varieties of oats, and that the virus from oats infects orchard grass. As with orchard grass, the percentage of oat plants developing signs of infection tends to be low. No infection has been evident in inoculated wheat, barley, sweet corn, smooth brome grass, smooth crabgrass, tobacco, Nicotiana tabacum, or Datura stramonium.

SYMPTOMS

In orchard grass, the leaf markings, for the most part, are typical of the grass mosaics, with a tendency to streaking. In some plants, the markings are very mild and evanescent. Fusiform chlorotic markings sometimes are prevalent. The markings range from faintly light-green to yellow, brown, and reddish-brown. Occasionally, chlorosis and/or necrosis are so severe in a plant as to become lethal to the entire plant when summer temperatures prevail. Leaf markings are illustrated in Figure 1.

In Letoria winter oats, the first signs of mosaic have tended to be weak. At temperatures near 75° F during the winter in a greenhouse, mottling soon disappeared from the leaves, which became bluish-green in color, and sometimes stiff and wiry. Light green to yellowish streaks sometimes appeared in the blue-green leaves, especially along one edge. The margins of these streaks usually were not sharp, but blended in with the blue-green color of the leaf. Some leaves were twisted in various shapes, and sometimes broke at several points along the edge. In many of the infected plants, internodal elongation was retarded early, and in others, this retardation was delayed; excessive tillering was induced, and growing points sometimes were killed. When there was a delay in the elongation of the internodes, the tillers tended to branch. Vegetation was greatly prolonged in the dwarfed plants. In many ways, the symptoms of these bluish green plants fit the brief description of the blue dwarf disease of oats (4). Leaf symptoms are illustrated in Figure 2, and dwarfed plants in Figure 3.

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[1] Acknowledgment is due Henry J. Breen and Lester W. Greeley for assistance in conducting these studies.

[2] Plant Pathologist, Field Crops Research Branch, Agricultural Research Service, United States Department of Agriculture.

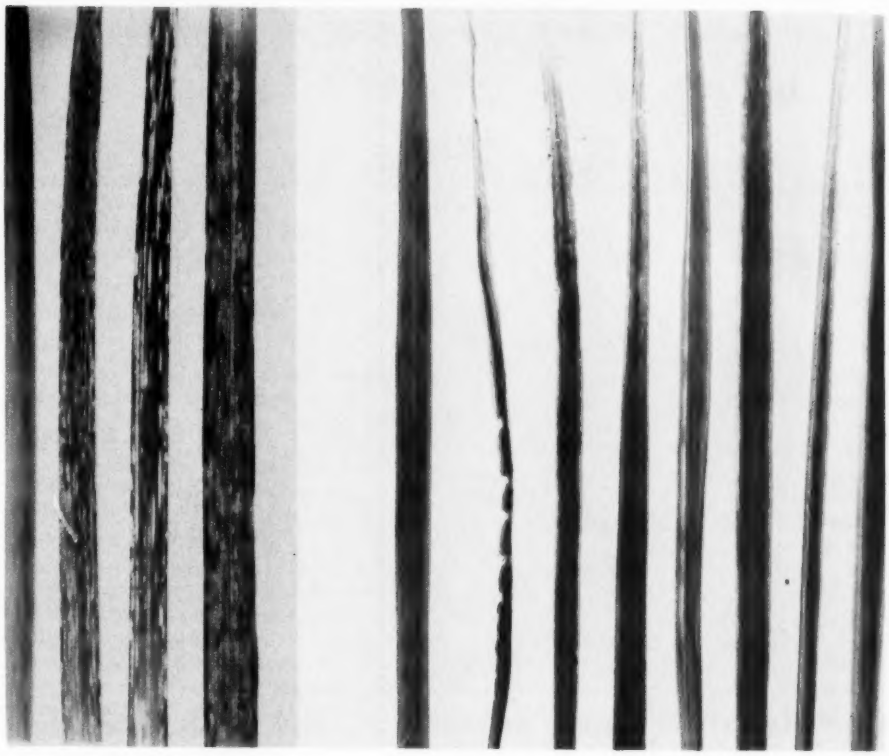

FIGURE 1. Leaf markings induced by a mosaic virus in orchard grass. Healthy leaf at left. Markings in the leaf at the right are several shades of brown.

FIGURE 2. Leaves of Letoria oats with chlorotic markings induced by the virus from orchard grass. These leaves are from the dwarfed plants illustrated in Figure 3.

Tests with other varieties of oats are incomplete, but signs of infection have been obtained in a few plants of Appler, Cody, Fulghum, and Victorgrain. With culture temperatures at 75° F during the night and on overcast days during April, leaf markings were very weak and evanescent in Appler and Cody, but they were fairly strong in Victorgrain and in some of the Fulghum plants. Reddish-brown spots and streaks appeared in some of the leaves of Victorgrain and Fulghum. At this writing, 7 weeks after inoculation, dwarfing is evident in the winter varieties but not in Cody, the spring variety. Attempts to detect synergy from a dual virus infection that accounts for blue dwarf in Letoria have been unsuccessful.

DISCUSSION

Although Letoria oats develop very striking blue dwarf symptoms when infected with the virus from orchard grass, further study is necessary to determine if this virus is involved in the blue dwarf disease that occurs in oats in the central spring-oat area, and to determine if the virus is the same as that causing cocksfoot streak in England. Dwarfs or rosettes may be induced by several factors. With the soilborne mosaic viruses of wheat (1) and in oats (3), rosetting occurs but, strangely enough, relatively few varieties of these hosts are susceptible to the rosette reactions. In experimental inoculation tests, dwarfs or rosettes were common in wheat and in barley as a result of synergistic reactions from dual infections with brome

FIGURE 3. Dwarfed plants of Letoria oats infected with virus, compared with a healthy Letoria control at left.

mosaic virus and certain strains of the barley stripe-mosaic virus (2). Moore's report (4) suggests the possibility that his oat blue dwarf may have resulted from a synergistic reaction involving a possible strain of the barley yellow dwarf virus, as he states that his blue dwarf was associated with aphid transmissible red-, orange-leaf reactions.

Smith (6) reports that the cocksfoot streak virus is transmitted with difficulty by manual methods of inoculation. Myzus persicae and Macrosiphum euphorbiae served as natural vectors of the virus. He obtained one streak-diseased plant out of several hundred raised from seed produced by streak-diseased cocksfoot (orchard grass) plants, but he seems not to be certain that the plants were kept free from viruliferous aphids throughout the test. There is no information concerning seed transmission of the writer's virus.

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FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE, BELTSVILLE, MARYLAND

RAPID INOCULATION TECHNIQUES FOR MECHANICAL TRANSMISSION OF SWEETPOTATO INTERNAL CORK VIRUS

E. M. Hildebrand[1]

Abstract

This report describes three rapid inoculation procedures for sweetpotato internal cork virus, employing respectively root, leaf, and petiole tissue as sources of inoculum. The method is an adaptation of Yarwood's quick virus inoculation method of rubbing freshly cut virus-infected tissue onto carborundum-dusted leaf surface sprayed with potassium-phosphate buffer solution.

Introduction

The method for rapid transmission of internal cork virus from sweetpotato to Scarlett O'Hara morning glory is a modification of a quick inoculation method devised by Yarwood (6). The process by which the virus enters the host cells can probably be explained by host cell reaction to a micrurgical inoculation technique (1, 2) in which minute amounts of virus are introduced into individual living plant cells (trichomes and epidermis) through a micropipette (1 to 3 microns in diameter). The operation, which is performed with a micromanipulator under the high power of a compound microscope, reveals what happens when the cell-wall plasma membrane is perforated by a minute needle or micropipette. Upon perforation there is an instananeous protrusion or pulsing action of the protoplasm[2], which momentarily extrudes through the opening and returns into the cell, bathing the tip of the wounding instrument for a fraction of a second (about 0.6 second).

Wounding with carborundum simulates the action of the micrurgical technique, and also approximates the process of natural infections. The momentary protrusion of the protoplasm is a rather general reaction when wounds are not lethal to the host cells, and probably always follows the perforation of epidermal cells. In essence, the so-called "rubbing method" of inoculation involves the production of minute non-fatal wounds.

For successful inoculation of plant cells with a virus, the wounds through which the virus is introduced must be sealed with protoplasmic plugs the instant that the protoplasm retracts within the cell walls. Thus for greatest success the inoculation instrument must be promptly removed after perforation occurs.

Procedure

A rapid inoculation technique that will liberate virus from diseased tissue and facilitate its immediate entry into susceptible host tissue is a requisite for the successful mechanical transmission of the highly unstable sweetpotato internal cork virus. In the method described wounds are produced in the host plant by rubbing while the virus is being squeezed out of infected tissue into a film of potassium phosphate buffer containing carborundum. The method is called "Modified Yarwood" (4) because it is derived from Yarwood's quick method (6) in which potassium phosphate was used as the buffer.

The inoculation technique used by the author from 1937 to 1944 (3) for the mechanical transmission of woody-plant viruses consisted of rolling a strip of leaf tissue into a tight cyl-

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[1] Pathologist, Vegetable Crops Section, Horticultural Crops Research Branch, Agricultural Research Service, Beltsville, Maryland.

[2] Hildebrand (1, p. 81): "An interesting observation was made which may give a clue as to one mechanism by which viruses gain entry into plant cells. When the micropipette perforates the trichome wall, protoplasm gushes out to form a hemispherical droplet which bathes the pipette tip momentarily and then returns into the cell. Turgor pressure from within or mechanical pressure from without or a combination of both may be responsible for the momentary expulsion of protoplasm but some other force as surface tension or release of mechanical pressure from without must operate to effect its return. It is considered probable that this phenomenon of momentary protrusion of protoplasm through a perforation in the wall of an injured cell supplies the reason why infections are more readily obtained when the virus extract is applied just before or during rubbing rather than afterward. It is rather apparent that since a similar reaction follows the perforation of epidermal cells other than hairs this phenomenon may be rather general in plants."

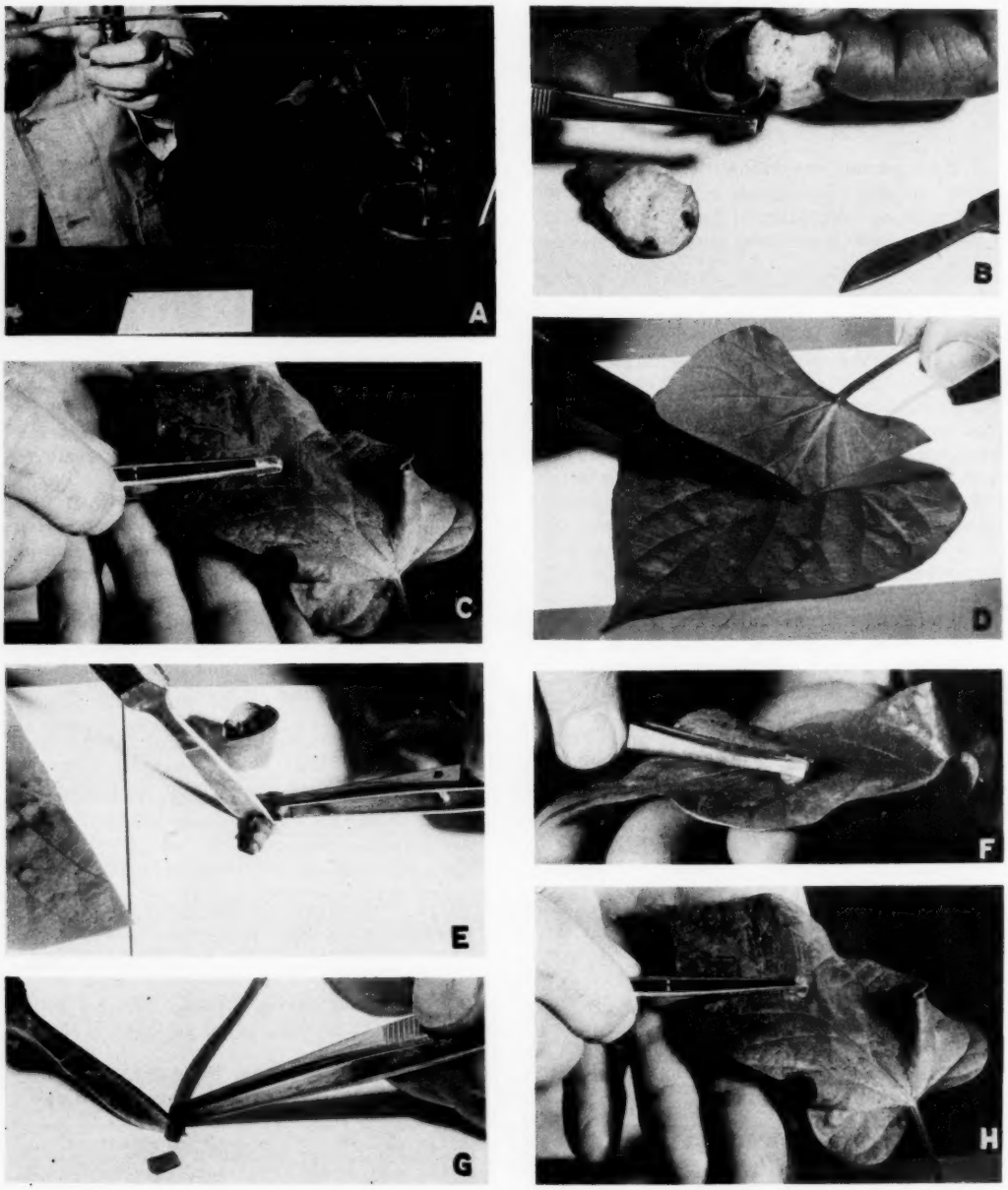

FIGURE 1. Rapid method for mechanical transmission of plant viruses. The leaves being inoculated are buffer-atomized and carborundum-dusted leaves on Scarlett O'Hara morning glory plants. A -- Atomizing the buffer (1% potassium phosphate) on leaf to be inoculated, just before dusting with carborundum. B -- Preparing cube of diseased root tissue. C -- Rubbing leaf with cube of diseased sweetpotato root squeezed within flat-tipped tweezers. D -- Excising strip of diseased sweetpotato leaf for rolling into a tight cylinder. E -- Cutting off a section of diseased leaf cylinder. F -- Inoculation by simultaneous squeezing and rubbing of diseased leaf cylinder section over leaf surface. G -- Petiole held in flat-tipped tweezers is cut to size. H -- Petiole section is simultaneously squeezed and rubbed over leaf surface.

inder, making a fresh transverse cut near the end, and squeezing the cylinder near the cut between the fingers while rubbing the freshly cut tissues gently over a leaf surface previously dusted with carborundum. Tight rolling was facilitated by first allowing partial wilting of the leaf tissue. For small quantities of inoculum it was advantageous to hold the tissue cylinder near one end in flat-tipped tweezers, make an even transverse cut, and rub the freshly cut surface of the cylinder on the susceptible host plant. The tweezers could be moved up the roll so that successive fresh cuts could be used. Because the finger method of holding and rubbing caused much mechanical injury of the leaf being inoculated, it was discarded in favor of tweezers, although injury could be reduced when the leaf surface was lubricated with a phosphate buffer (pH 6-7). To prevent cross-contamination the tweezers and scalpel were dipped in alcohol and flame-sterilized. The operator also washed his hands in soapy water between inoculations.

Some of the materials needed for making inoculations with sweetpotato internal cork virus are 1% potassium phosphate buffer, atomizer for applying buffer, carborundum in salt shaker, Bunsen burner and alcohol for flaming flat-tipped tweezers and scalpel, inoculum consisting of sweetpotato leaf and root showing symptoms, and healthy plants of the indexing hosts.

For infection of Scarlett O'Hara or other indicator plants with internal cork virus, the growth stage of the indexing host is important. For example, when a seedling of Scarlett O'Hara has more than four leaves, it should be pruned back to the first leaf to insure symptom development on the first new growth, for symptoms do not develop on inoculated or mature leaves although they contain virus. Incidentally, such a quick-growing young plant as Scarlett O'Hara produces leaves as rapidly as one a day so that in 5 days symptoms are usually beginning to appear on one or more of the new leaves, and by the seventh day two or more leaves may have positive symptoms of chlorotic vein banding. Figure 1 A illustrates the application of 1% potassium phosphate buffer to a pruned Scarlet O'Hara morning glory. Before pruning, this plant had seven leaves; if it had not been pruned it would have had to be staked and would not have shown symptoms until 10 to 15 days had elapsed.

Three sources of internal cork virus inoculum have been employed: 1) root tissue, 2) leaf tissue, and 3) petiole tissue.

Since internal cork lesions in roots commonly run lengthwise a diseased root is sliced crosswise to show the lesions, starting at the stem end. Figure 1 B shows a slice containing two dark spots. The tissue outside the necrotic spots is cut away, cubes of darkened tissue are carved with a scalpel, and a cube ready for inoculating a leaf is held by flat-tipped tweezers. In Figure 1 C a leaf of Scarlett O'Hara morning glory is being inoculated by rubbing with a cube of diseased root tissue squeezed with flat-tipped tweezers. Squeezing forces out the viruliferous sap, which bathes the carborundum as the latter produces the microscopic wounds to effect inoculation.

Leaf inoculum is prepared by excising a strip of leaf tissue (Figure 1 D). The amount needed is very small, but here about half a leaf is used. The next step is to roll the strip into a cylinder with the upper surface outside. Allowing the excised leaf tissue to stand for a few minutes makes it easier to roll a tight, firm cylinder. Held by flat-tippec tweezers, the leaf tissue cylinder is next cut to size (Figure 1 E) for use in inoculation (Figure 1 F).

The internal cork virus cannot withstand desiccation. During collection in the field leaves showing symptoms for indexing may dry out. By accident it was found that the petioles of partially dried diseased leaf blades of sweetpotato stood up well and were still turgid after a week at room temperature, and could be indexed readily. The petiole is excised as shown in Figure 1 G. If the petiole cylinder is squeezed gently while held by flat-tipped tweezers both ends exude a convex meniscus of sap (Figure 1 H). The leaves of sweetpotato are tougher and easier to inoculate, and are less subject to injury than leaves of morning glory when inoculated by this method.

To recapitulate, the inoculation procedure must be planned carefully and executed with speed and precision. The preliminaries before inoculation include preparation of the indexing host and labeling and systematic arrangement of each pot on the inoculation table. Immediately after inoculation the plants are transferred to the greenhouse bench, sprinkled with water, and covered by newspaper until the following morning.

Discussion

Yarwood (6) demonstrated a procedure superior to conventional juice inoculation methods, especially for unstable viruses. It involved rubbing the cut edges of discs from leaves of infected plants onto carborundum-dusted potassium phosphate-sprayed leaves of test plants.

Yarwood advanced the hypothesis that "phosphate increases susceptibility by its chemical action in increasing the size and number of cell perforations started by the act of inoculation by rubbing the leaf surface" (5). The effectiveness of the basic method with the very highly unstable sweetpotato internal cork virus suggests rather that the effect of the potassium phosphate buffer is to lubricate, to prevent chemically deleterious action of the host tissue sap on the virus, and to protect the wounds and exposed protoplasm by filming over the leaf surface.

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HORTICULTURAL CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, BELTSVILLE, MARYLAND

CORRELATION OF OCCURRENCE OF POTATO VIRUS Y WITH AREAS OF POTATO PRODUCTION IN FLORIDA[1]

J. N. Simons, Robert A. Conover, and James M. Walter[2]

Abstract

Three strains of potato virus Y (veinbanding mosaic virus) have been found in three geographically separated areas of south Florida. In these regions this virus causes a major disease in peppers and/or tomatoes. All three areas either now have or else have had commercial potato production as part of their agricultural history. Two other regions where tomatoes and peppers are grown extensively do not have potato virus Y present insofar as is known. Neither of these two latter regions have had a history of commercial potato production prior to this year.

If potatoes were the source of the original introduction of potato virus Y in the areas of present prevalence, it is suggested that within a few years this virus may appear as a disease in tomatoes and peppers in these new areas of potato growing.

Potato virus Y is now recognized as one of the most important of the viruses commonly causing mosaic diseases of tomatoes and peppers in certain south Florida vegetable-growing areas. Previous reports have dealt with its occurrence and importance on tomatoes in the Homestead area[3] and on peppers in the Belle Glade area[4]. Recent work has shown the virus to be prevalent also on peppers and tomatoes in the Bradenton area and on peppers in the Homestead area.

During the past year collections of the virus from peppers and tomatoes have been taken from all three of the above areas and their symptoms have been compared on a limited number of host plant species. The results of these trials are shown in Table 1.

The symptoms produced in the various plants were the same insofar as any one species or variety was concerned, with the following exceptions. Tomato inoculated with the Homestead isolate at times reacted with necrotic spotting on old and young leaves. None of the other isolates ever produced this reaction. Under field conditions at Homestead, necrosis is a prominent feature of virus Y infections of tomatoes (3). Zinnia showed a faint mottle in response to both the Belle Glade and Homestead isolates and virus was readily recovered by rubbing to Turkish tobacco. However, the Bradenton isolate caused no symptoms in zinnia and numerous recovery attempts were all negative.

Tabasco pepper inoculated with any of the three isolates always reacted with a severe mottle. The wilting symptom which is characteristic of tobacco-etch virus infection was not observed[5]. No local lesions were produced on Physalis peruviana L. The systemic mottle which did occur would also indicate that these isolates were not closely related to the tobacco-etch virus[6].

These results indicated that the same virus was probably involved in all cases. Although the reaction on tomatoes and zinnia was variable, depending on the isolate used, this would probably mean only that closely related strains of one virus were involved.

There are two other large areas of tomato and pepper production in south Florida in ad-

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[1] Florida Agricultural Experiment Station Journal Series, No. 488. The authors are indebted to Mr. E. King for the preparation of the map and to Mr. Henry Spelman III for making the photograph.

[2] Assistant Virologist, Everglades Experiment Station, Belle Glade, Florida; Plant Pathologist, Sub-tropical Experiment Station, Homestead, Florida; and Plant Pathologist, Gulf Coast Experiment Station, Bradenton, Florida, respectively.

[3] Conover, Robert A., and Robert W. Fulton. 1953. Occurrence of potato virus Y on tomatoes in Florida. Plant Dis. Reptr. 37: 460-462.

[4] Simons, John N. 1956. The pepper veinbanding virus in the Everglades area of south Florida. Phytopathology 46: 53-57.

[5] Greenleaf, W. H. 1953. Effects of tobacco-etch virus on peppers (Capsicum sp.) Phytopathology 43: 564-570.

[6] Holmes, F. O. 1942. Quantitative measurement of a strain of tobacco-etch virus. Phytopathology 32: 1058-1067.

Table 1. Reaction of certain plant species to three isolates of potato virus Y.

Species	Belle Glade isolate	Bradenton isolate	Homestead isolate
Capsicum frutescens L.			
var. California Wonder	+	+	+
var. Tabasco	+	+	+
Lycopersicon esculentum Mill.			
var. Rutgers	+	+	+[b]
Nicotiana glutinosa L.	+	+	+
Nicotiana tabacum L			
var. Turkish	+	+	+
Physalis peruviana L.	+	+	+
Solanum gracile Link	+	+	+
Zinnia elegans L.	+	-[a]	+

[a] Attempts to recover virus to N. tabacum were all negative.

[b] This strain causes necrosis in tomato but the other strains do not.

dition to those near Belle Glade, Bradenton, and Homestead. The largest of these is on the East Coast, running somewhat intermittently from about Pompano in the South, to Vero Beach in the North (Fig. 1, #2). A second centers at Immokalee (Fig. 1, #4). Potato virus Y has not been found to date in either. Neither is separated by more than 50 miles from one of the sections where potato virus Y is prevalent. It should be noted, however, that these five areas are effectively isolated in an ecological sense from each other by barriers such as swamps and metropolitan areas.

The reason why some of these sections have potato virus Y present and others do not is rather puzzling. Since known weed hosts of this virus are common to all, this would not seem to be the limiting factor. Suitable vectors abound in all. One is led to suspect that some other common denominator is necessary to explain the situation.

The most obvious correlation is that the regions where potato virus Y is present all have histories of commercial potato production while the other districts are negative in this respect. This leads one to believe that the virus is not native to south Florida but may have been introduced through potato plantings. The differences in symptomatology and host ranges among the three isolates, which might be interpreted to mean separate introductions of the virus from different potato seed-producing areas, supports this hypothesis.

The evidence at hand indicates that once introduced into an area, potato virus Y is readily maintained from season to season, presumably on weed hosts. Present outbreaks of the virus on peppers and tomatoes show no discernible relationship to potato crops in the areas concerned.

The principal potential value of this hypothesis might come in allowing the prediction that potato culture in areas where potato virus Y is not present, but where peppers and tomatoes are grown, could have serious consequences. Commercial potato acreages have been planted during this past year in the two areas in which the virus has not been found (Fig. 1, #2 and #4). Known weed hosts of the virus are common in both. Based on the evidence presented, one might predict that if potato culture continues in these areas, potato virus Y will likely become a problem on pepper and tomato crops. Should that occur, the losses due to the introduction of a new disease might more than offset the possible gain from a new crop.

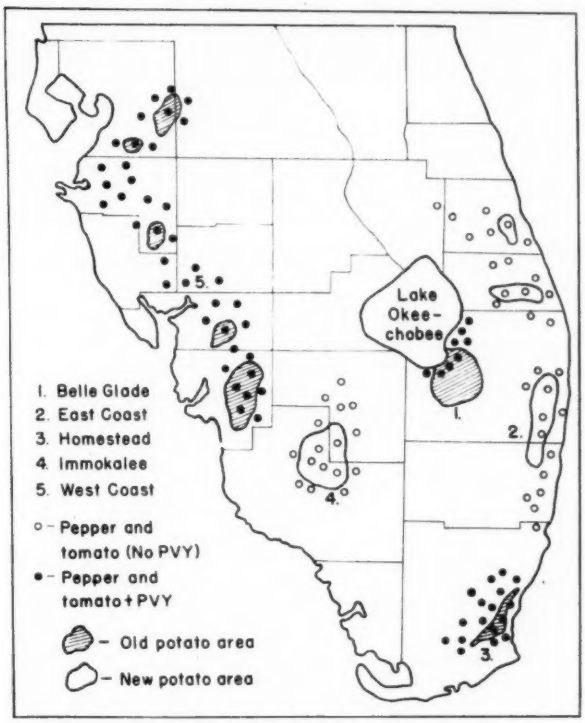

FIGURE 1. Semi-diagrammatic map showing occurrence of potato virus Y on pepper and tomato in south Florida as correlated with areas of potato production. Note that regions where potatoes have been grown for many years are the only areas where the virus has been found.

EVERGLADES EXPERIMENT STATION, BELLE GLADE, FLORIDA SUB-TROPICAL EXPERIMENT STATION, HOMESTEAD, FLORIDA, GULF COAST EXPERIMENT STATION, BRADENTON, FLORIDA

THE GROWTH AND DEVELOPMENT OF PHYTOPHTHORA INFESTANS FROM POTATO TUBERS IN STEAMED SOIL[1]

J. R. Wallin and Dale N. Polhemus[2]

Summary

Potato tubers were inoculated with Phytophthora infestans through needle wounds. The inoculated tubers were held at room temperature for 17 days to allow the pathogen to develop. On the 17th day when the tubers were cut and planted in steamed soil, the lesions on the tubers varied in size from 1 mm to 2.5 cm in diameter.

Four days after planting, mycelium and sporangia of P. infestans were noted on the surface of five pots. Forty-eight hours later only mycelium could be found.

The first sprouts emerged from the blighted seed pieces in 7 and the last in 27 days after planting. Only 21 percent of the blighted seed pieces produced sprouts in that time while 100 percent of the non-blighted seed pieces produced sprouts.

Only one diseased shoot was noted in the blighted series. Rhizoctonia solani, soft-rot bacteria, and nematodes were obtained from the necrotic tissue of this shoot.

Positive late blight symptoms were not identified on any of the shoots that emerged from the blighted seed pieces.

Rhizoctonia solani, nematodes and bacteria were found in a greater percentage of the blighted than of the non-blighted tubers. Apparently infection by P. infestans encouraged the development of the other organisms.

Two types of nematodes were found in the necrotic tissue of a collapsed potato shoot. The nematodes seemed to fit the description of two saprophytic species. These nematodes were found in 10 percent of the non-inoculated and 65 percent of the inoculated seed pieces.

Growth of the late blight pathogen, Phytophthora infestans (Mont.) D By., from the infected tuber into the sprout and thence to the foliage was first suggested as a hypothesis 110 years ago (2). Since then it has been observed in potato fields in Europe and the United States. However, this phase of the life cycle of the pathogen, although frequently sought, is seldom observed.

The first record of the spread of the potato late blight fungus from blighted tubers up into the shoots and into the foliage was De Bary's, published in 1861 (1).

In 1915 (7), in numerous greenhouse and field trials in Iowa, the late blight fungus was noted to grow from blighted tubers up into the sprouts, where it sporulated and spread to adjoining plants.

In Ireland (8), progress of the late blight pathogen, through growth from blighted tubers up into the shoots, sporulation, and infection of new foliage, was observed in the field. Sprouts penetrated by the fungus failed to emerge, but from these sprouts the fungus spread into the surrounding soil and remained alive for a limited period, in one instance as long as 57 days. Furthermore, the pathogen spread from infected sprouts to attack the newly formed tubers.

In Russia in 1939 (9), the late blight pathogen was found to retain its virulence in diseased tubers for at least one vegetative season, and to sporulate on the soil surface when tuber remnants were raised by earthworms or cultural practices. This study indicated that the primary source of inoculum was the young infected sprout.

During investigations in Maine published in 1943 (3), over a 10-year period only one commercial field was noted in which late blight originated from a diseased tuber. In addition, in a planting of naturally infected late blight-diseased tubers, only 4 percent of the resulting sprouts were blighted.

In Russia in 1952 (6), primary leaf infection was found to occur exclusively from sporangia

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[1] Journal Paper No. J-2933 of the Iowa Agricultural Experiment Station, Ames, Iowa. Report of an investigation conducted under the Regional Crop Disease Forecasting Project of the Research and Marketing Act (RMA Title II) in cooperation with the Iowa Agricultural Experiment Station, Project 1163.

[2] Plant Pathologist and Agent (Biological Aid), respectively, United States Department of Agriculture, Horticultural Crops Research Branch. Plant Disease Epidemics and Identification Section, Ames, Iowa.

that developed either on the surface of diseased tubers or on young sprouts in the soil. The same year in Yugoslavia (4), results of a study of late blight-diseased tubers indicated that the late blight fungus originating from partially blighted tubers may grow through the soil and attack young sprouts produced by the same or adjacent tubers. The fungus rapidly killed the sprouts before they could emerge.

In England in 1954 (5) trials conducted with inoculated tubers revealed that the sprouts from 3 of 8 tubers inoculated with P. infestans developed basal necrosis. The fungus was recovered from one stem at heights of 16 and 24 cm. The results were considered as strong evidence that the pathogen grew up the stem from the tubers.

In our own studies during the past 8 years, the initial movement of the late blight pathogen from the tuber up the sprout and into the foliage has been an enigma. Potato fields surveyed in May and June when the young plants were erect and sparsely foliated seemed blight-free. At least, typical late blight symptoms were not detected among the various types of lesions noted on the young plants. The stems and/or leaves of plants ranging in height from 2 to 24 inches exhibited many spots, streaks, and flecks. In many instances, late blight symptoms appeared later in the season, in July and August, in fields earlier reported as blight-free. On 2 occasions during the past 8 years, the primary source of inoculum in potato fields was traced to one or two hills. In these instances, one or two of the three or four stems in the hill were dead and the others dying.

This delayed appearance of the pathogen aroused considerable interest and speculation as to the behavior of the pathogen during the earlier stages of its development. Many explanations are possible, e.g., (a) the diseased plants constituting the primary source of inoculum may have been overlooked, (b) the diseased plants may have exhibited atypical symptoms not readily diagnosed by casual observation, (c) young, minute lesions may have been obscured from view by sand and soil deposited on the young stems, petioles, and leaflets by rain, wind, and cultivation, and (d) a few late blight-diseased sprouts may have emerged undetected late in the season after the vines had formed a dense canopy.

In order to obtain more information concerning the development of the late blight pathogen from diseased tubers, a study was made of the response of Irish Cobbler tubers inoculated with the late blight pathogen and planted in steamed soil in the greenhouse. The results and conclusions of the study appear herein.

Tuber Inoculation

Forty Irish Cobbler tubers were washed and scrubbed thoroughly with detergent and water and then inoculated with sporangia from a 14-day-old pea culture of Isolate 1. Each tuber was punctured in two different places at least 1 cm away from the nearest eye. Mycelium bearing viable sporangia was placed in the wounds. The inoculated tubers were held in the greenhouse at room temperature for 17 days. By this time, the size of the diseased area surrounding the punctures ranged from 1 mm to 2.5 cm in diameter. Next, the tubers were halved or quartered according to their size and planted an inch deep in steamed soil in 4-inch pots.

The pots were grouped according to the size of the infected area of the seed piece: 20 pots contained seed pieces with diseased areas 2.5 cm in diameter; 60 pots contained seed pieces with smaller lesions.

Twenty pots were planted with uninoculated seed pieces as checks.

Results and Conclusions

Four days after planting, scattered clumps of white mycelial growth resembling Phytophthora infestans were noted on top of the soil covering the heavily infected seed pieces. Microscopic examination revealed mycelium and sporangia of P. infestans on the soil surface of 5 of the 20 pots containing the heavily infected seed pieces.

Forty-eight hours after the sporangia were noticed on the soil surface they were no longer present.

This phenomenon, although it was observed under artificial conditions, seems especially significant because it suggests a means by which the late blight fungus spreads from the tuber to the potato foliage. Certainly a few clumps of mycelium bearing sporangia on the soil surface would tend to obscured from view, and even if noticed, probably would not be recognized as P. infestans.

The first potato sprouts emerged from the blighted seed pieces 7 days, and the last 27 days after planting (Table 1).

Table 1. Percentage emergence from blighted and non-blighted seed potato pieces planted in steamed soil.

Number of days after planting	Percent of emergence from Blighted seed pieces	Non-blighted seed pieces
7	1	10
14	15	95
16	18	100
27	21	100

Obviously, P. infestans inhibited sprout development in 79 percent of the inoculated seed pieces. Furthermore, the greatest emergence occurred during the first 14 days after planting, and the rate of emergence from the blighted seed pieces was slower than that from the non-blighted seed.

Thirty-three days after planting, one sprout from an infected seed piece collapsed from a collar rot at the soil surface. Microscopic examination of the sprout revealed Rhizoctonia solani, bacteria, and nematodes in the diseased tissue. Phytophthora infestans was not observed.

Upon discovery of nematodes in the diseased sprout, additional observations were made. Samples of soil and tuber tissue from all pots were taken with a cork borer 0.5 cm in diameter. A search for microorganisms in these samples was made with a microscope. The findings are summarized in Table 2.

Table 2. Percentage of blighted and of non-blighted tubers yielding various organisms.

Organism	Percentage from tubers: Blighted	Non-blighted
Phytophthora infestans	2	0
Nematodes	65	10
Rhizoctonia solani	80	10
Bacteria	91	15
No organisms	5	

Some of the tubers were so badly rotted that they yielded only soft-rot bacteria. Only a small number of tubers yielded P. infestans. Interestingly, tubers inoculated with P. infestans contained the greatest percentage of nematodes. Obviously, presence of the late blight fungus enhanced the development of the other organisms.

Late blight symptoms were not found on any of the sprouts that emerged and developed. However, the young potato sprouts were held at such low relative humidities on the greenhouse bench that growth of the pathogen may have been inhibited.

Two kinds of nematodes were noted in the soil-tuber plugs obtained from the pots. The results from the microscopic studies indicated that both kinds were saprophytes. Apparently, the invasion of the tissue by P. infestans greatly enhanced the development of nematodes. Interestingly, the nematodes were sufficiently deep in the tuber to survive the detergent wash.

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UNITED STATES DEPARTMENT OF AGRICULTURE, HORTICULTURAL CROPS RESEARCH BRANCH, PLANT DISEASE EPIDEMICS AND IDENTIFICATION SECTION, AMES, IOWA

RELATIVE SUSCEPTIBILITY OF POTTED SEEDLINGS OF JUGLANS REGIA, J. HINDSII AND PTEROCARYA STENOPTERA TO PHYTOPHTHORA CINNAMOMI[1]

P. W. Miller and L. F. Roth[2]

Abstract

In two different greenhouse experiments, inoculated potted seedlings of Juglans regia and J. hindsii were found to be susceptible to Phytophthora cinnamomi. Inoculated potted seedlings of Pterocarya stenoptera did not become infected.

In 1922, Phytophthora cinnamomi was named and described by Rands (3) from cultures isolated from cankers on cinnamon trees in Sumatra. The fungus has since been reported as infecting over 100 different species of plants in many parts of the world (4).

P. cinnamomi was first reported on Juglans species (J. nigra L. and J. regia L.) by Crandall in 1936 (1). In 1945, Crandall et al. (2) reported the production of a root rot on J. nigra by inoculation with pure cultures of P. cinnamomi isolated from decayed roots of eastern black walnut (J. nigra) and Persian walnut (J. regia) seedlings. However, inoculations of the eastern black walnut with isolates of P. cinnamomi from chestnut caused no infection. In 1954, Torgeson (5) reported that 11 different isolates of P. cinnamomi, including five from Oregon, were pathogenic on J. regia in greenhouse tests.

Attempts to isolate this fungus from rotting roots of dying walnut trees in orchards in Oregon with specialized Phytophthora-culture techniques (5) have been unsuccessful so far. Nevertheless, in view of the fact that P. cinnamomi was recently reported in Oregon (5) it was deemed advisable to determine by inoculation the relative susceptibility of the various rootstock species on which walnut trees are grown in Oregon.

The most important walnut rootstock species in Oregon are J. hindsii Sarg. and J. regia L. In recent years some interest has developed in the Chinese wingnut (Pterocarya stenoptera DC.) as a rootstock for Persian walnut. Because of this interest, the Chinese wingnut also was included in the experiments.

Materials and Methods

Two experiments were conducted: the first in 1954 and the second in 1955. In the 1954 inoculations, nine 2-year old trees of each of the three species used as rootstocks were inoculated when they were in full leaf and an equal number of each species were left uninoculated as checks. In 1955, ten 3-year old trees of each species were inoculated just as they were beginning to leaf out and an equal number of each species were uninoculated. All trees were healthy, field-grown seedlings that showed no evidence of root infection at the time of digging. They were planted individually in pots in autoclaved soil and allowed to become established prior to inoculation.

The culture of Phytophthora cinnamomi used for the 1954 inoculations was isolated by Torgeson (5) from roots of Lawson cypress. Pure cultures of the fungus isolated from rhododendron, Lawson cypress, heather, forsythia, and yew were mixed together and used for inoculation in 1955. The fungus was grown in pea broth by the standard procedure. Before use for inoculations, the cultures were agitated vigorously to break up the fungus masses. Ten cubic centimeters of the pea broth suspension was poured into each of two holes 4 inches deep in the soil on opposite sides of each tree. The holes were then filled with soil.

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[1] Approved for publication by the Director of the Oregon Agricultural Experiment Station and by the Chief of the Horticultural Crops Research Branch, Agricultural Research Service, United States Department of Agriculture. Contribution of the Department of Botany and Plant Pathology of the Oregon Agricultural Experiment Station and the Horticultural Crops Research Branch.

[2] Plant Pathologist, Horticultural Crops Research Branch and Associate Plant Pathologist, Department of Botany and Plant Pathology, Oregon State College, respectively.

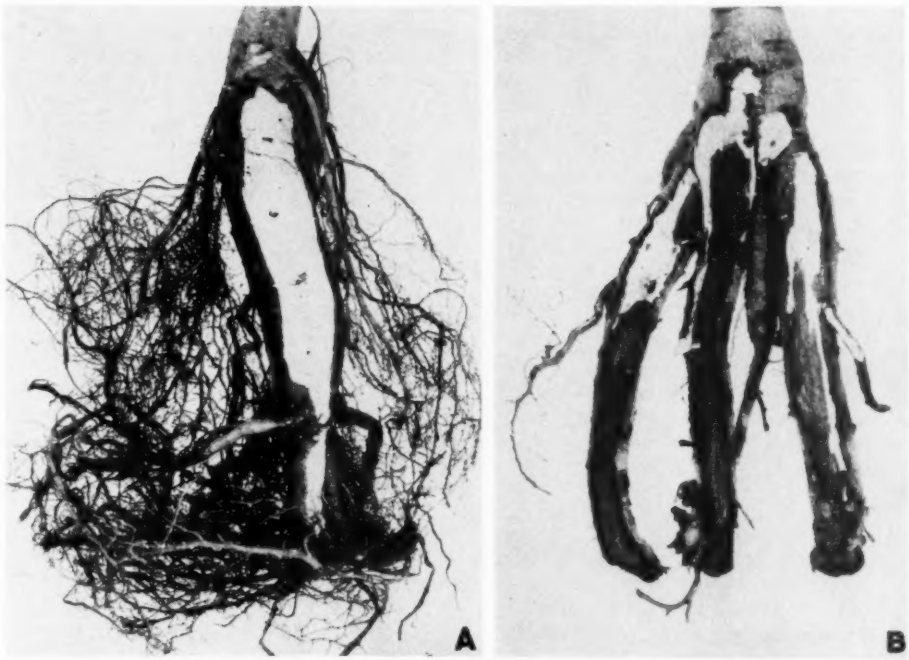

FIGURE 1

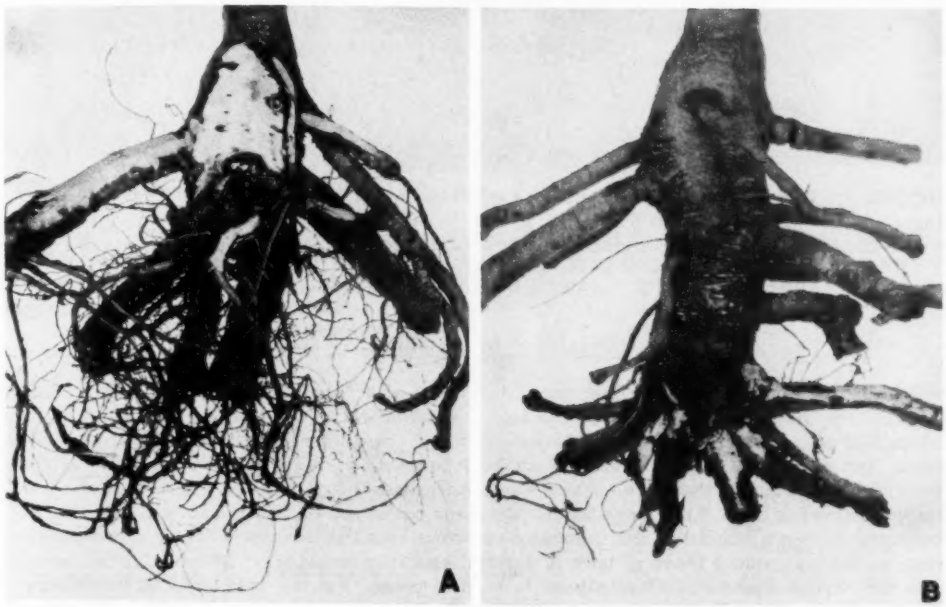

FIGURE 2.

Representative root systems of walnut seedlings grown in: A, autoclaved soil; B, soil infested with Phytophthora cinnamomi, March 8, 1955. Photographs by H. H. Millsap, Jan. 26, 1955. FIGURE 1 -- Persian walnut (Juglans regia). FIGURE 2 -- Hinds black walnut (J. hindsii).

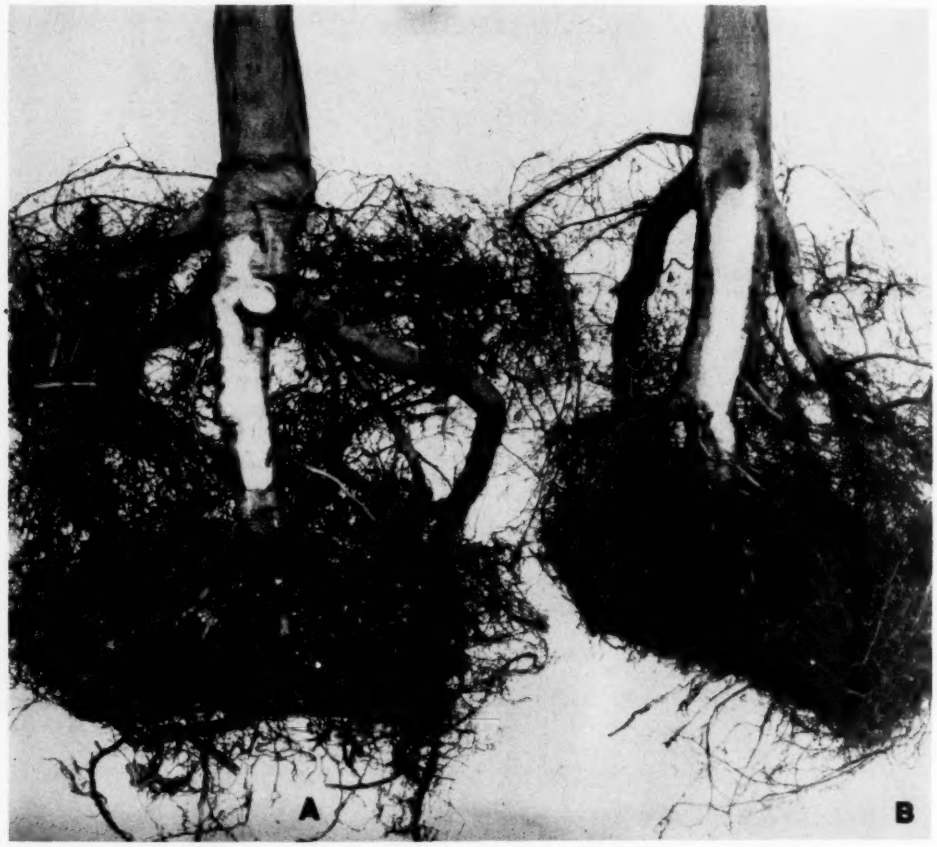

FIGURE 3. Representative root systems of Chinese wingnut (Pterocarya stenoptera) seedlings: A, grown in autoclaved soil; B, grown in soil infested with Phytophthora cinnamomi March 8, 1955. Photographs made on January 26, 1956, by H. H. Millsap.

Results of Inoculations

In the first experiment, one of the inoculated trees of J. regia showed evidence of disease 46 days after the inoculum was added to the soil. The leaves turned yellow, and a few of the lower ones fell off. After 92 days, all the inoculated J. regia seedlings showed definite foliage symptoms, but symptoms were not visible on the inoculated J. hindsii or P. stenoptera trees. The roots of all inoculated and check trees were examined 200 days after addition of the inoculum and the following conditions were noted: Lesions occurred on the primary roots of all of the inoculated J. regia seedlings and almost no fibrous roots remained. Fibrous roots were numerous on the inoculated trees of both J. hindsii and P. stenoptera. Some infection was apparent in the fibrous roots of all inoculated J. hindsii trees, but the primary and secondary roots were not affected. There was no indication of infection in the inoculated P. stenoptera trees. The root systems of the inoculated P. stenoptera trees were more extensive than those of the other species and fibrous roots were abundant. The root systems of all uninoculated check trees of all three species were free from lesions and fibrous roots were abundant. P. cinnamomi was isolated from two typical lesions on the primary roots of J. regia and from one typical lesion on a small root of J. hindsii.

In the second experiment disease symptoms were few and poorly defined in the tops of the

inoculated trees. However, when the roots were examined 324 days after addition of the inoculum, numerous lesions were found on both the primary and the secondary roots of all of the inoculated J. regia trees and few fibrous roots remained (Figure 1, B). Lesions also occurred on the roots of six of the inoculated J. hindsii trees, but on this host they were primarily on the secondary and fibrous roots; most of the fibrous root system was destroyed (Figure 2, B). No lesions that could be definitely ascribed to P. cinnamomi were found on any part of the root system of the inoculated P. stenoptera trees, and the fibrous root systems were extensive (Figure 3, B). As in the first experiment, the root systems of all the uninoculated check trees of all three species were free from disease lesions and fibrous roots were abundant (Figures 1, A; 2, A; 3, A).

P. cinnamomi was isolated from eight typical lesions (12 isolation attempts made) on the primary roots of J. regia and from two typical lesions (7 isolation attempts made) on the secondary roots of J. hindsii.

Conclusions

A comparison of the relative severity of root damage on the three species inoculated and the results of isolations indicate that Pterocarya stenoptera is highly resistant to the strains of Phytophthora cinnamomi tested. Both Juglans regia and J. hindsii are susceptible.

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HORTICULTURAL CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE AND DEPARTMENT OF BOTANY AND PLANT PATHOLOGY OF THE OREGON AGRICULTURAL EXPERIMENT STATION COOPERATING

BORON IN RELATION TO FOLIAR AND FRUITING ABNORMALITIES OF PEACH[1]

A. C. McClung and C. N. Clayton

Abstract

Several instances of suspected boron deficiency of peach trees have been observed in the Sandhills area of North Carolina. The disorder is characterized by reduced leaf size, greatly shortened internodes, excessive branching, reduced fruit set and yield, and occurrence of internal necrosis in the fruit. The disorder was associated with very low levels of boron as gauged by leaf and twig analysis. Erractic occurrence of the systems at a given site has interfered with field experimentation and prevented a more definite diagnosis of the disorder.

Introduction

There is little literature dealing with boron deficiency of peach trees under field conditions. Although the occurrence of boron deficiency of peach is mentioned (5, 10) and symptoms obtained in solution culture are described (14), the only detailed description of symptoms under field conditions is that of McLarty and Woodbridge (11). In addition to symptoms these workers gave some analytical data related to the probable deficiency. They failed to give any data showing corrective or preventative effects of an improved boron supply, however, and leave some doubt as to their positive diagnosis of the disorder.

The erratic occurrence of boron deficiency symptoms of woody perennial plants has been reported by several investigators who have dealt with this problem (1, 3). It has not been uncommon to establish experimental plots in severely affected orchards and then pass through several seasons in which tree growth and fruit development appear normal on both treated and untreated trees. In some cases this has probably delayed full evaluation of the importance of boron deficiency for a particular crop or area. This situation was encountered in North Carolina. Symptoms suspected to be those of boron deficiency were noted on a number of occasions, but they failed to reappear on a particular site and satisfactory experimentation was not completed. A number of observations and analyses were made, however, and these are presented with the view that they may provide a useful background for further study of this problem.

Symptoms

Vegetative symptoms observed in spring and early summer are shown in Figures 1 to 3. The abnormality is characterized by extremely reduced leaf size and shortened internodes, Figure 1. Lateral shoots on normal twigs were about 8 to 10 inches long when these photographs were made (early May), while those on affected twigs were often less than an inch in length. The abnormal shoots usually have as many nodes as normal shoots. Lateral branching occurs at least as frequently on these extremely shortened shoots as on the normal shoots, Figure 2. Such branching occurs without death of the terminal bud. Seriously affected leaves are smaller than the stipules but stipular size is about normal. Margins of the less seriously affected leaves are chlorotic with dark green tissue along the mid-rib. The dark green area is sometimes flecked with tiny chlorotic spots. Leaves are often asymmetrical with irregular margins. A slight chlorosis may occur on trees which do not show any other vegetative symptoms but may later display fruit symptoms. The retarded condition of a seriously affected tree is shown in Figure 3. It is unusual to find entire trees affected this severely except for those 1 or 2 years of age. It is not uncommon to find branches or parts of larger trees seriously affected while the remainder shows none of the vegetative symptoms.

In most cases apical dominance appears lacking and virtually every vegetative bud makes some growth. Very severely affected trees are exceptions to this general pattern. In some cases individual branches or even whole trees remain completely inactive even though normal in outward appearance. No injury to woody portions of such trees is evident and death does not occur until gradual dessication takes place in early summer. Very few trees have been found to be affected this severely and the number of trees actually killed has been low.

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[1] Published with the approval of the Director of Research, North Carolina Agricultural Experiment Station, as Paper No. 731 of the Journal Series.

FIGURE 1. Shoot growth on normal and abnormal peach twigs.

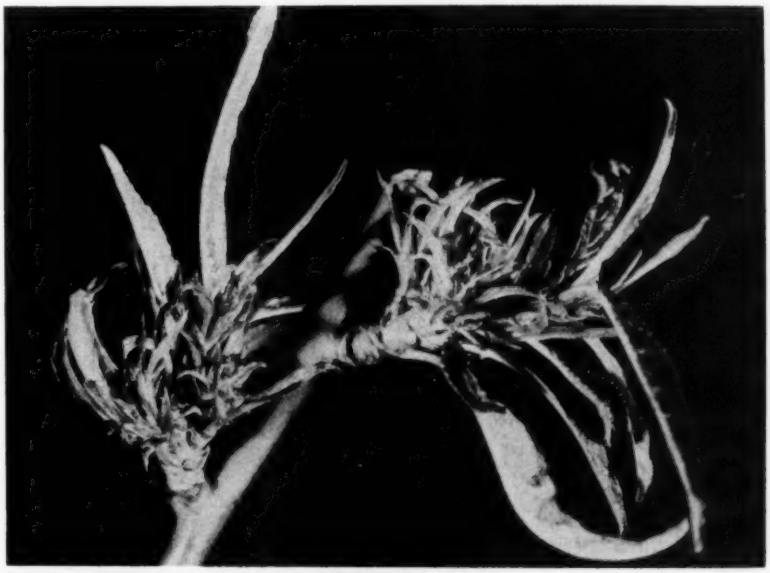

FIGURE 2. Close-up of affected peach shoots.

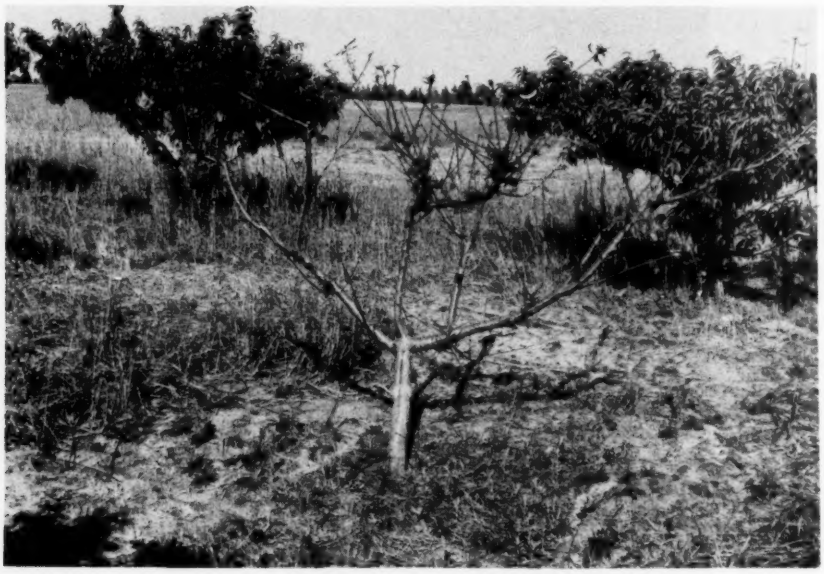

FIGURE 3. Golden Jubilee peach tree showing advanced vegetative symptoms.

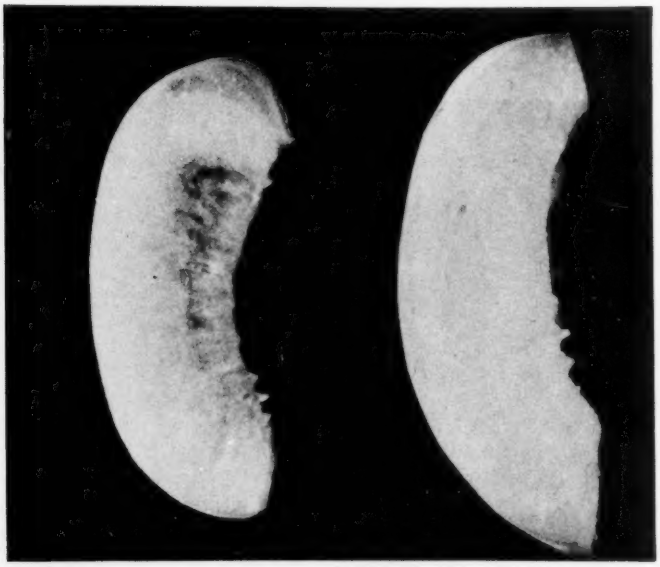

FIGURE 4. Internal fruit necrosis. Normal fruit on right.

As the season progresses normal shoot growth occurs from most of the active buds. By mid-summer all but the most severely affected trees are normal in general appearance. The small early spring leaves abscise and the only noticeable evidence of the early condition is the unusually large number of shoots. Lateral branching on extremely shortened shoots results in the unusual situation of several shoots arising from almost the same point. By the end of the season these lateral shoots are often 8 to 10 inches in length and give the appearance of clustered laterals on wood of the previous season.

Flower number is probably not greatly reduced except on the most severely affected trees. Fruit set is greatly reduced. Many affected trees produce no fruit and few, if any, have a full commercial crop. Fruit set may be reduced to a low level on trees displaying none of the vegetative symptoms. There is no breaking or abnormal appearance of flowers on affected trees and abscission occurs at about normal petal-fall stage.

Fruit symptoms consist of somewhat early ripening and the formation of necrotic areas around the pit (Figure 4). Size and outward appearance of affected fruit is normal. Internal necrosis may be found on trees without the vegetative symptoms and on those with only mild reduction in fruit set.

These symptoms have been noted on many of the commercial varieties grown in the Sandhills area. They have been found most commonly on trees 2 to 4 years of age but have also occurred on fully mature trees. Although the occurrence at any one site may be erratic, the symptoms have appeared at some location each year since they were first observed in 1951.

Because of the general virus-like appearance of the vegetative symptoms attempts were made to transmit the disorder by budding. Buds from several affected areas were grafted over a 2-year period. In no instance was the syndrome induced by budding.

Leaf and Twig Analyses

In August 1952 mid-shoot leaf samples were collected from 150 individual trees in an orchard in which symptom expression had varied from trees apparently normal to trees that produced no fruit and showed advanced vegetative symptoms. The boron content of all leaf samples was very low but no correlation was found between level of boron and symptom expression. (Boron analyses reported in this paper were by the methods of Ellis (6) and Naftel (11). Certain of those referred to but not reported were by the method of Curran et al. (3). Master samples carried through all analyses and some experimental samples studied by more than one procedure showed no significant differences between methods). Boron contents varied from 7.0 to 15.0 ppm with most samples containing less than 12.0 ppm. Spectrographic analyses indicated apparently adequate levels of other nutrients. These boron contents were low relative to those found for samples of mid-shoot leaves collected in a survey of the Sandhills conducted in 1952 (8). Survey samples contained a mean of 24.9 ppm boron and varied from 16.0 to 38.0 ppm. None of these trees were known to have displayed symptoms.

In 1953 severe symptoms were again noted in this orchard and experimental treatments were established with the goal of increasing the boron level for certain trees and decreasing it for others. Variables consisted of an untreated check, boron application, liming to above neutrality, sheltering much of the root system with a waterproof covering, and deep subsoil tillage close to the trees. Boron content of the leaves was affected only where boron was applied. Subsequent to the initiation of the experiment a slight amount of internal fruit necrosis was the only symptom found in the orchard. While this did not occur on boron-treated trees the incidence was too low to be conclusive. Foliage analyses for boron-fertilized and nonfertilized trees were made in 1954 and are given in Table 1. A total of 0.90 pounds of borax had been applied in 6 equal increments by the end of the 1954 season. These additions were made in 3 applications at about 6-week intervals from March 15 to June 15 each year. Boron contents of mid-shoot leaves of the untreated trees were as low as those previously associated with severe symptoms. Samples from the boron-treated trees greatly increased in boron content to a level approaching toxicity. Fruits from fertilized trees softened prematurely and were of poor color and insipid flavor. The foliage was darker in color on the boron-treated trees and shoot growth continued slightly later in the season.

Twig analyses were made in February, 1955. Samples collected from 5 2-tree plots of each treatment consisted of terminal sections of 1954 growth 8 to 10 inches in length and 1/8 to 1/4 inch in diameter. Mean boron content for untreated trees was 8.8 ppm and for those receiving boron applications 53.8 ppm.

Table 1. Boron content of leaf samples collected in 1954 (ppm).

Leaf Position	Date of Sampling					
	5/4	5/25	6/18	7/14	8/11	9/1
			No Boron Applied			
Basal	11.8	12.2	10.0	10.4	12.6	15.0
Mid-Shoot	9.8	8.4	7.6	7.8	9.6	11.6
Terminal*	11.2	12.0	12.0	12.2	15.0	15.6
			Boron Applied			
Basal	44.4	43.6	42.8	49.2	56.3	50.8
Mid-Shoot	81.8	60.4	66.8	77.6	77.6	56.6
Terminal*	154.2	85.6	106.8	130.8	105.0	62.6

* Terminal leaf samples consisted of youngest unfolded leaves subtending the terminal cluster.

Soil Conditions in Relation to Symptoms

The symptoms described above have been noted in orchards planted on soils of the Lakeland or Eustis series. These soils are deep sands with a base exchange capacity in the plow layer of from 1.5 to 3.0 me per 100 grams. Soils from this area have been found to contain from 0.03 to 0.10 ppm boron determined by the boiling water procedure of Berger and Truog (2) and for sensitive crops deficiencies are not uncommon. Soil analyses were carried out in conjunction with the observations reported here. Symptoms were found in orchards in which soil pH varied from 4.8 to 6.0, a range in which approximately optimum boron availability might be expected.

Compaction of the subsoil appeared to be related to the occurrence of symptoms. A number of instances was noted in which trees planted in abandoned farm roadways were severely affected while all other trees were normal. Symptoms on young trees were found more frequently in replanted orchards and in orchards on old cultivated land than on virgin sites. This could have been related to soil compaction or to other factors.

Soil moisture conditions in relation to the occurrence of symptoms are of interest, particularly in view of the common observation that boron deficiency is often associated with drouth. The vegetative symptoms described above were found during the spring and early summer when moisture conditions were good. There did not appear to be a relationship between soil moisture and extent of the disorder during the period in which symptoms occurred. There appeared to be a possible correlation between drouth in late summer and fall and symptom development the following spring. Greater incidence of the disorder was suspected in orchards with heavy crotalaria cover. This might have resulted from greater moisture stress or from direct competition for a limited boron supply. In one orchard it was calculated that the cover contained boron equivalent to 0.04 ppm of soil, assuming all removal from the surface 6 inches.

Discussion

Two factors in the present study are suggestive of boron deficiency. First, and perhaps most convincing, is the general agreement with the symptomatology of boron deficiency as reported for other crops and the general similarity to the report for peaches (11). Shortened internodes, excessive branching, dwarfed leaves, and internal fruit necrosis are all symptoms in common with those reported by Burrell (3) and others for boron-deficient apple trees. Greatly reduced fruit set, fruit symptoms, and excessive branching have been described for boron deficiency of olive trees (13). Shortened internodes and extreme branching were noted for grape vines (8). Reduced fruit set of pears has been shown recently to be due to an incipient boron deficiency (1).

Vegetative symptoms for peach in Canada described by McLarty and Woodbridge (11) appear to follow the same over-all pattern observed here but detailed comparisons are not possible. One difference appears to be in the incidence of death of vegetative buds that have initiated growth. This situation was not observed in North Carolina but was apprently common in the Canadian orchards.

The symptoms described in the present report are not the same as those found in minus-boron mutrient solution (14). In solution culture actual death of all terminal buds occurred. This was followed by initiation of new laterals which were simiarly affected in a short time. These responses are in agreement with reports of acute deficiency for other species.

McLarty and Woodbridge (11) noted a heavy reduction in fruit set similar to that found here. Observations concerning the development of internal necrosis in the fruit have not previously been reported.

Leaf analyses provide a second indication of possible boron deficiency. The boron contents found in affected orchards are in a range that has been associated with deficiency in many crops (1, 6, 10, 11). The samples from affected trees were much lower than those from unaffected orchards. Failure to establish a relationship between boron content and severity of symptoms in a seriously affected orchard is not strong evidence against a role of boron in the disorder. Foliar analysis as a diagnostic tool is frequently ineffective in differentiating between deficiency and adequacy at a threshold point.

More definite diagnosis of this disease will require demonstration of a preventative or corrective action of added boron. Such work can probably best be carred out in the field in spite of the difficulties of erractic occurrence noted above. It seems probable that a threshhold boron level exists in affected orchards and that these symptoms, if they are due to boron deficiency, are brought about by slight changes in boron status possibly related to weather and other environmental conditions. It would be very difficult to duplicate such a borderline situation in solution culture for a long enough period to produce vegetative symptoms and at the same time to avoid the acute symptoms cited for culture solution studies above. Fruit symptoms would be even more difficult to duplicate.

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DEPARTMENT OF SOILS AND DEPARTMENT OF PLANT PATHOLOGY, NORTH CAROLINA STATE COLLEGE, RALEIGH, NORTH CAROLINA

STRAINS OF COTTON RESISTANT TO BACTERIAL BLIGHT[1]

D. M. Simpson

Bacterial blight (Xanthomonas malvacearum (E. F. Sm.) Dowson) occurs throughout the cotton-growing areas of the world. In the United States, the estimated reduction in 1955 cotton yield caused by this disease was 222,611, or 1.08 percent loss. In this country, losses from the disease are greatest in the Southwest, particularly in the irrigated areas of New Mexico and Arizona, and in the dry-land areas of Texas and Oklahoma. Losses up to 50 percent of the crop have been reported where the disease has occurred in epiphytotic form.

Two races of the causal organism are now recognized and at least seven independent factors for resistance have been reported. The major genes required for resistance to races 1 and 2 of the blight organism are now available in American upland cottons. Collectively, these resistant strains of cotton represent an extremely wide range of agronomic types and provide a valuable source of basic breeding material. Through the efforts of the Bacterial Blight Committee of the Cotton Disease Council these basic breeding stocks are now available in limited quantities to interested plant breeders, geneticists, and agronomists. A list of the varieties and strains available together with a brief description of each and sources of seed are listed in the following table.

[1] Compiled by D. M. Simpson, Chairman, Bacterial Blight Committee.

Table 1. Seed source and varietal description of cotton varieties resistant to bacterial blight, Xanthomonas malvacearum (E.F.Sm.) Dowson.

Source of seed	U. S. Cotton Sta. Knoxville, Tennessee		Arkansas Cotton Branch Sta. Marianna
Strain Designation	Stoneville 20	B-251	BBR-1
Origin	Stoneville 2A	St. 20 x(Trice x Tidewater)	Stoneville 2B
Resistant to X. mal. Race #	#1	#1 and 2	#1
Resistant Genes	b_7	b_7, other	b_7
Plant Type	Eastern, early	Eastern, early	Eastern, early
Bolls per pound	65-70	60-65	Average bolls
Lint percent	37-39	38-40	34.7
Lint length (32's)	32-35	32-34	1.13
Lint Fineness (A)	440-465	400-425	423
Lint Strength (T_1)	---	1.90-2.10	7.09 (P.I.)
Yield (comparative)	Poor	Good	Good
Seed Available	Breeding stocks	Bulk	Small amount
Special properties	Tester line	----	----

Source of seed	Arkansas Cotton Branch Sta. Marianna		ARS, Field Crops Branch University Station Baton Rouge, Louisiana
Strain Designation	BBR-3	BBR-4	2014
Origin	Stoneville 2B	Stoneville 2B	St. 20 x DPL 14-312
Resistant to X. mal. Race #	#1	#1	#1 and 2
Resistant Gene	b_7	b_7	b_7, other
Plant Type	Eastern, early	Eastern, early	Eastern, early
Bolls per pound	Average bolls	Average bolls	80-85
Lint percent	34.0	33.7	37-39
Lint lengths (32's)	1.09	1.17	32-35
Lint Fineness (A)	436	461	----
Lint Strength (T_1)	6.82 (P.I.)	6.83 (P.I.)	----
Yield (comparative)	Good	Fair	Good
Seed Available	Small amount	Small amount	Breeding stocks
Special properties	----	----	----

Table 1. (Continued).

Source of seed	ARS, Field Crops Branch University Station Baton Rouge, Louisiana		Texas Agr. Exp. Sta. College Station, Texas
Strain Designation	2014-BX	1-11-1	S3-
Origin	St. 20 x DPL 14-312 1 backcross	Stoneville 2B background	(St. 20 x St. 2B) 3 backcrosses
Resistant to *X. mal.* Race #	#1	#1 and 2	#1
Resistant Genes	b7, other	b7, other	b7
Plant Type	Eastern, early	Eastern, early	Eastern
Bolls per pound	75-80	75-80	70-80
Lint percent	37-39	36-38	35-37
Lint Length (32's)	32-34	32-34	30-32
Lint Fineness (A)	----	----	370-400
Lint Strength (T_1)	----	----	1.60-1.70
Yield (comparative)	Good	Good	Fair
Seed Available	Breeding stocks	Breeding stocks	Breeding stocks
Special properties	----	----	----

Source of seed	Texas Agr. Exp. Sta. College Station, Texas		
Strain Designation	D4-	Austin	Ac4-28-2
Origin	(St. 20 x St. 2B) 4 backcrosses	(St. 20 x Empire) 3 backcrosses	Selection from California Acala
Resistant to *X. mal.* Race #	#1	#1	#1 and 2
Resistant Genes	b7	b7	Unknown
Plant Type	Eastern	Eastern	Western Acala
Bolls per pound	80-90	70-80	50-60
Lint percent	37-40	38-40	38-40
Lint Length (32's)	31-33	30-32	32-33
Lint Fineness (A)	360-380	400-430	370-400
Lint Strength (T_1)	1.60-1.70	1.70-1.80	1.70-1.80
Yield (comparative)	Fair	Good	Unknown
Seed Available	Breeding stocks	Bulk	Breeding stocks
Special properties	----	----	----

Table 1. (Continued).

Source of seed	Texas Agr. Exp. Sta. College Station, Texas		
Strain Designation	AE-	K6E-	K6S
Origin	Selection from Pima 32	BAR 4/16 x Empire (6 backcrosses)	BAR 4/16 x St. 2B, 6 backcrosses
Resistant to X. mal. Race #	#1 and 2	#1 and 2	#1 and 2
Resistant Genes	Unknown	B_2 and B_3	B_2 and B_3
Plant Type	Barbadense	Eastern	Eastern
Bolls per pound	----	55-65	60-65
Lint percent	----	33-34	34-36
Lint Length (32's)	----	32-33	31-33
Lint Fineness (A)	----	400-440	420-445
Lint Strength (T_1)	----	1.60-1.70	1.60-1.70
Yield (comparative)	----	Unknown	Unknown
Seed Available	Breeding stocks	Breeding stocks	Breeding stocks
Special Properties	----	----	----

Source of seed	Texas Agr. Exp. Sta. College Station, Texas		
Strain Designation	K6D	DLo	St. Lo
Origin	BAR 4/16 x Deltapine 6 backcrosses	Selection from Deltapine 15	Selection from Stoneville 2B
Resistant to X. mal. Race #	#1 and 2	#1	#2
Resistant Genes	B_2 and B_3	b_7	Unknown
Plant Type	Eastern	Eastern	Eastern
Bolls per pound	55-70	----	----
Lint percent	34-39	----	----
Lint Length (32's)	32-34	----	----
Lint Fineness (A)	380-440	----	----
Lint Strength (T_1)	1.70-2.00	----	----
Yield (comparative)	Unknown	----	----
Seed Available	Breeding stocks	Breeding stocks	Breeding stocks
Special Properties	----	----	----

Table 1. (Continued).

Source of seed	Texas Agr. Exp. Sta. College Station, Texas		
Strain Designation	MaLo	102-1-1	ME-
Origin	Selection from Macha	Selection from tri-species material	Mebane B1 x E3-
Resistant to X. mal. Race #	#2	#1 and 2	#1 and 2
Resistant Genes	Unknown	Unknown	b_7 + Mebane B1 Gene
Plant Type	Storm Proof	Stormproof	Eastern
Bolls per pound	----	70-80	50-70
Lint percent	----	37-39	35-40
Lint Length (32's)	----	31-33	31-33
Lint Fineness (A)	----	400-440	400-430
Lint Strength (T_1)	----	1.50-1.60	1.70-2.00
Yield (comparative)	----	Fair	Unknown
Seed Available	Breeding stocks	Breeding stocks	Breeding stocks
Special Properties	----	----	----

Source of seed	Oklahoma Agr. Exp. Sta. Stillwater, Oklahoma		
Strain Designation	8-3-4-B2-1	CR-4	17-3-4-B3
Origin	Half-and-Half	C.A. 122 Ey.	Lankart 57
Resistant to X. mal. Race #	#1	#1 and 2	#1 and 2
Resistant Genes	b_7	Unknown	Unknown
Plant Type	Open	Small, close	Very leafy, open
Bolls per pound	----	75-85	50-60
Lint percent	34	36-38	34-36
Lint length (32's)	35	29-31	30-33
Lint Fineness (A)	----	Coarse	----
Lint Strength (T_1)	----	Very strong	----
Yield (comparative)	Fair	Good	Fair
Seed Available	Bulk	Bulk	Bulk
Special Properties	Very early	Stormproof	Very late

Table 1. (Continued)

Source of seed	Oklahoma Agr. Exp. Sta. Stillwater, Oklahoma		
Strain Designation	20-8-1-3-6	1-10-B-4-B-2	2-B-4-B-4 B-2
Origin	Northern Star	Unidentified	Unidentified
Resistant to X. mal. Race #	#1 and 2	#1 and 2	#1 and ?
Resistant Genes	B_N[a]	B_I[a]	B_H[a]
Plant Type	Open	Very limby	Semi-cluster
Bolls per pound	----	----	----
Lint percent	34-36	28-30	----
Lint length (32's)	32-34	----	Short
Lint fineness (A)	Medium	----	Coarse
Lint Strength (T_1)	----	----	----
Yield (comparative)	----	Poor	----
Seed Available	Breeding stock	Breeding stock	Breeding stock
Special Properties	----	Stormproof	----

Source of seed	Oklahoma Agr. Exp. Sta. Stillwater, Oklahoma		New Mexico Agr. Exp. Sta. State College, New Mexico
Strain Designation	6-77-5-8-2	P.I. 201,626	Acala 1517 BR
Origin	Stormproof #1	Ethiopian Intro.	(St. 20 xAc. xAc. xAc. xAc.)
Resistant to X. mal. Race #	#1 and ?	#1 and ?	#1
Resistant Gene	B_N[a]	Unknown	b_7
Plant Type	Open	Open	Acala, short, early
Bolls per pound	----	----	60-65
Lint percent	----	----	36-38
Lint lengths (32's)	Short	----	34-36
Lint Fineness (A)	----	----	425-475
Lint Strength (T_1)	----	----	1.85-2.05
Yield (comparative)	----	----	Good
Seed Available	Breeding stock	Breeding stock	Bulk
Special Properties	Stormproof	----	----

[a] Oklahoma tentative designation.

Table 1. (Continued).

Source of seed	New Mexico Agr. Exp. Sta. State College, New Mexico		
Strain Designation	8373-	9136-	250-
Origin	Intr-spec. cross and recombination	As 8373-, plus Tanguis	BR Acala (St. 20) x 8373
Resistant to X. mal. Race #	#1 and 2	#1 and 2 (weak)	#1 and 2
Resistant Gene	Unknown	Unknown	b_7, other
Plant Type	Acala, late	Acala, late	Acala
Bolls per pound	60-65	60-65	55-60
Lint percent	34-36	36-38	37-39
Lint length (32's)	37-40	35-37	34-36
Lint fineness (A)	450-500	450-500	425-475
Lint Strength (T_1)	1.80-2.00	1.90-2.10	1.90-2.10
Yield (comparative)	Fair	Good	Good
Seed Available	Breeding stocks	Breeding stocks	Breeding stocks
Special Properties	----	Verticillium tolerant	----

Source of seed	U. S. Cotton Field Sta. Greenville, Texas	Texas Agr. Exp. Sta., No. 8 Lubbock, Texas
Strain Designation	Mebane B1	Blightmaster
Origin	Mebane Buchellew	(St. 20 x Acala 5676) x Stormmaster
Resistant to X. Mal. Race 3	#1 and 2	Race 1
Resistant Gene	Unknown	B_7
Plant Type	Western	Semi Spreading, early
Bolls per pound	77	75-85
Lint percent	35.6	38-40
Lint length (32's)	32	30-32
Lint Fineness (A)	445	3.8-4.0
Lint Strength (T_1)	1.55	84-87
Yield (comparative)	Good	Good
Seed Available	Bulk	Bulk
Special Properties	Tester line	Stormproof boll, Adapted to stripper harvest

INFLUENCE OF PLANTING DATES ON FUNGI ISOLATED FROM DISEASED COTTON SEEDLINGS[1]

N. D. Fulton, B. A. Waddle, and R. O. Thomas[2]

Summary

Temperature during seedling growth has been shown to have a significant influence on the species of fungi isolated from diseased cotton seedlings. Rhizoctonia solani and Fusarium spp. are considerably more active at lower temperatures than Colletotrichum gossypii, Sclerotium bataticola, and Rhizopus sp. A fungicide, PCNB, when applied in the furrow at planting time has effectively inhibited both R. solani and S. bataticola, but has shown little activity against C. gossypii, Fusarium spp. or Rhizopus sp.

In 1954 the Arkansas Experiment Station and the United States Department of Agriculture set up a cooperative experiment with replicated cotton plots at Osceola, Arkansas, in an attempt to differentiate between cotton seedling damage by soil microorganisms and possible injury to seedlings by an herbicide. The work gave no conclusive results in regard to this objective, but did produce some interesting information on the fungi associated with cotton seedling disorders.

Materials and Methods

The plots were located on a uniform soil tentatively classified as Dundee very fine sandy loam and the same seed lot was used throughout the series. The cotton was planted at early, medium and late dates with three treatments and a check plot included in each instance. All treatments and the check were replicated four times. Treatments consisted of a fungicide (PCNB)[3], an herbicide (Dow Premerge)[4], and a combination of both materials. PCNB was applied as an aqueous solution around the seed in a narrow band in the furrow at planting time. The application rate was 5 pounds per acre in 5 gallons of water. Dow Premerge was applied on a 16-inch band at the rate of 3 pounds active per acre.

A month after planting 80 diseased seedlings were taken from each treatment and the check plots. After surface sterilization with sodium hypochlorite tissue transplants were made on both potato dextrose and water agars. After several days' incubation, the plates were examined and isolates identified. In Table 1 are listed the principal fungi isolated with their relative prevalence indicated by the percentage in parentheses after each fungal name. Percentages were based only on numbers of the fungi known to be pathogenic to cotton seedlings. Certain fungi such as Penicillium spp. and Aspergillus spp. were not included even though isolated since their pathogenicity has not been established. A graphic representation of the average temperature for the 30 days following each planting date is shown in Figure 1.

Results and Discussion

As shown in Table 1, the activity of individual members of the soil microorganism complex varies as the season progresses. There is, of course, no real assurance that all fungi listed here are pathogenic to cotton seedlings, but there is general agreement that Rhizoctonia solani Kuehn, Fusarium moniliforme Sheldon, and Colletotrichum gossypii South. can be involved. Results here show R. solani to have a very important role early in the season at lower soil temperatures and a somewhat less prominent one as temperatures rise. Apparently the strains of R. solani attacking cotton are able to grow over a relatively wide temperature range. However, even when R. solani was practically eliminated by the fungicide in the early planting the decreased competition allowed fungi (Fusaria) to increase their activity. C. gossypii appears to become important only as temperatures become higher since this fungus was not isolated until

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[1] Published with the approval of the Director of the Arkansas Experiment Station.

[2] Assistant Plant Pathologist, Arkansas Experiment Station; Associate Agronomist, Arkansas Experiment Station; Physiologist, Field Crops Research Branch, Agricultural Research Service, U. S. Department of Agriculture, respectively.

[3] Pentachloronitrobenzene (Terraclor) furnished by Olin Mathieson Company.

[4] Dinitro-ortho-secondary-butyl-phenate.

Table 1. Fungi isolated from diseased cotton seedlings coming from three different dates of planting.

Treatment	Date of Planting		
	April 30	May 20	June 4
Check (No treatment)	Rhizoctonia solani (100)[a]	Sclerotium bataticola (75) Rhizoctonia solani (25)	Rhizoctonia solani (50) Sclerotium bataticola (25) Fusarium moniliforme (25)
PCNB	Fusarium spp. (35) Fusarium moniliforme (50) Rhizoctonia solani (15)	Colletotrichum gossypii (15) Fusarium moniliforme (15) Fusarium spp. (70)	Colletotrichum gossypii (100)
Dow Premerge	Rhizoctonia solani (100)	Fusarium spp. (80) Sclerotium bataticola (20)	Colletotrichum gossypii (50) Rhizopus sp. (50)
PCNB Dow Premerge	Fusarium moniliforme (80) Rhizoctonia solani (20)	Colletotrichum gossypii (60) Fusarium spp. (20) Fusarium moniliforme (20)	Fusarium spp. (100)

[a] Numbers in parentheses after fungi indicate per cent of total pathogenic fungi isolated.

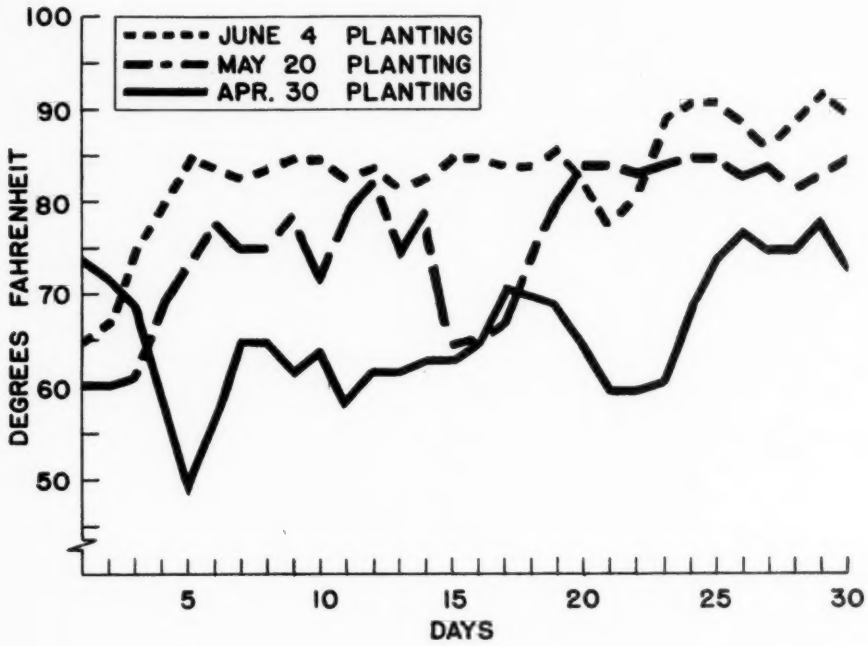

FIGURE 1. AVERAGE DAILY TEMPERATURES FOR THE 30 DAYS FOLLOWING EACH PLANTING.

the May 20th planting. Sclerotium bataticola Taub. and Rhizopus sp. are included in the table both because of their prevalence among the isolates and because they have been implicated in cotton seedling disorders to some extent.

In these plots treated with PCNB a marked reduction in the activity of both R. solani and S. bataticola is evident, but at the same time little or no effect on the other fungi is indicated. This phenomenon of specificity has been reported repeatedly and would appear to be one of the most important factors in the search for soil fungicides to control cotton seedling blights. To be effective, a material must act on not one or two but all organisms which might conceivably injure the cotton seed or seedling.

ARKANSAS AGRICULTURAL EXPERIMENT STATION AND AGRICULTURAL RESEARCH SERVICE, U. S. DEPARTMENT OF AGRICULTURE COOPERATING

DESIGN AND CONSTRUCTION OF A COMPACT BATTERY OF CONSTANT-TEMPERATURE TANKS FOR COTTON SEEDLING DISEASE INVESTIGATIONS[1]

C. D. Ranney

Summary

The design and construction of constant-temperature tanks for accurate control of soil temperatures above and below ambient is described and illustrated. Observations relative to accuracy and reliability of temperature control are made.

Testing of fungicides applied in the seed furrow at time of planting in an effort to reduce damage due to the cotton seedling disease complex has been carried out for the past several years at the Texas Agricultural Experiment Station. Results of field tests at numerous locations over the State have been extremely variable. Applications of fungicides which apparently give good control under some conditions may be completely ineffective under others. Results indicate the necessity of controlling as many environmental factors as possible, especially soil temperature and moisture, in order to obtain a true understanding of the effectiveness of soil-applied fungicides in reducing the severity of the seedling disease complex.

In 1954, a series of four constant-temperature tanks[2] was built in the greenhouse at this Station. These were patterned after those developed at the University of Wisconsin by Jones, Johnson and Dickson (2), following in part the modifications noted by Leukel (3) and Campbell and Presley (1), so as to permit controlled temperatures below the ambient room temperature. As only the seedling stage is to be studied the number of pans per bath was increased so as to permit more replicated treatments.

Design and Testing

The entire unit is 15 feet 5 inches long, 4 feet 8 inches wide, and 3 feet high. Each of the four controlled-temperature baths is 48 inches long, 33 inches wide, and 18 inches deep. The cold water storage tank is similar in size except it is 30 inches deep. All tanks are constructed of 20-gauge galvanized sheet iron and painted with corrosion-resistant Plicote paint. The tanks are supported by a 4x4- and 2x4-inch frame work which is covered on the outside by exterior grade masonite. Both external and internal walls and the bottom of the unit are insulated with a 4-inch layer of coarse vermiculite. Space does not permit full construction details but Figures 1 to 3 will illustrate many of them.

Each tank has a capacity of 24 pans, each of which is 13 inches long, 3 inches wide at the top, 2 inches wide at the bottom, and 6 inches deep, as illustrated in Figure 4. The pans are made of 24-gauge galvanized sheet iron and are water-tight. To avoid possible chemical action between the soil and the galvanized iron the pans were painted with Plicote paint. With pans of this size it is possible to plant 24 cotton seed 1 inch apart, each 1 inch from the side of the pan. The pans are held in place in the tank by inverted lengths of 1x1x1/8-inch Tee-iron. Although the pans used were designed especially for cotton seedlings, modification to accommodate other seedlings should be simple. The water level of each tank is controlled by a tank outlet which maintains the water in the bath at 3/8 of an inch below the top of the pans. The return line from the constant temperature tanks to the storage tank has a 2-inch drop per 12 feet; while this works satisfactorily under most conditions, it is suggested that the drop be increased for more efficient operation.

The controlled soil temperature bath provided four accurately controlled temperature levels. A 1/2 horsepower drop-in-type milk cooler refrigeration unit is used to cool water in the storage tank. With this unit a relatively large amount of water can be kept cold (40° F), and the unit requires little attention. Cold water is supplied to the various temperature tanks by a series of thermostatically controlled water pumps, which upon demand pump cold water from

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[1] Work reported forms part of a thesis presented to the Graduate School of the A & M College of Texas in partial fulfillment for the degree of Master of Science in August 1955.

[2] A grant-in-aid from the R. T. Vanderbilt Co., 230 Park Avenue, New York, for the purchase of components used in this unit is gratefully acknowledged.

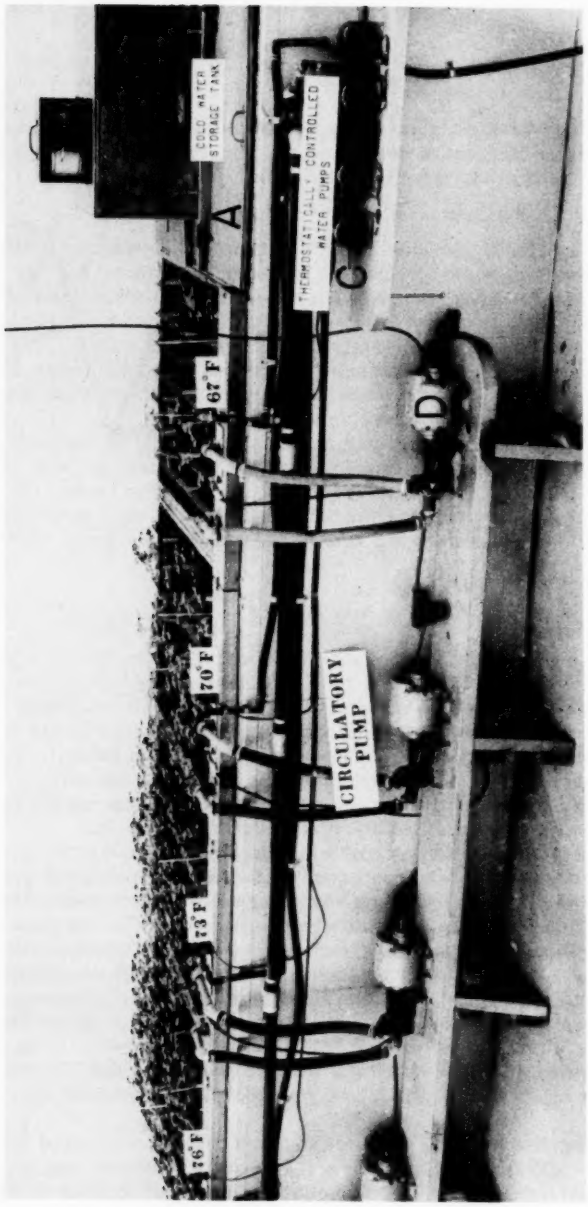

FIGURE 1. General view of controlled soil temperature tanks. Water is cooled and stored in the covered tank (A), by a drop-in refrigeration unit (B). Cold water is supplied to individual tanks by small pumps (C), each controlled by a thermostat. Water is circulated in each tank by centrifugal pumps (D) to assure uniform temperature through each tank.

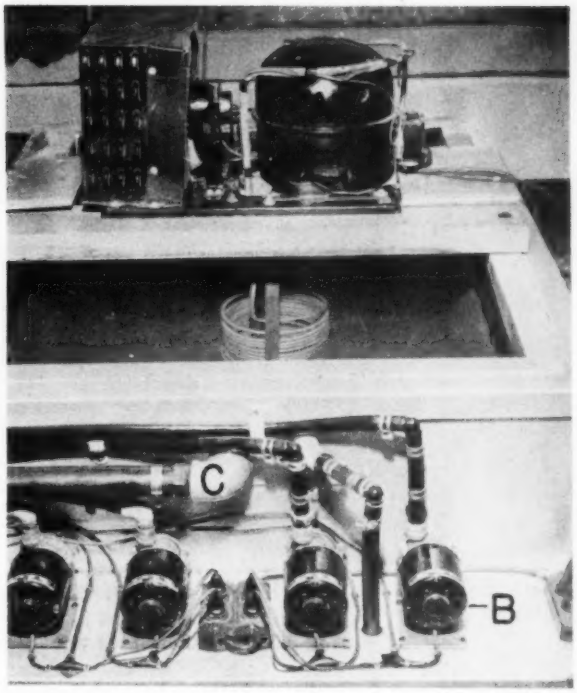

FIGURE 2. Relationship of refrigeration unit and cold water supply pumps. Water is cooled by a drop-in type unit (A) and is pumped to individual tanks by thermostatically controlled pumps (B). Overflow from the controlled temperature tanks returns (C), to storage tanks for recooling.

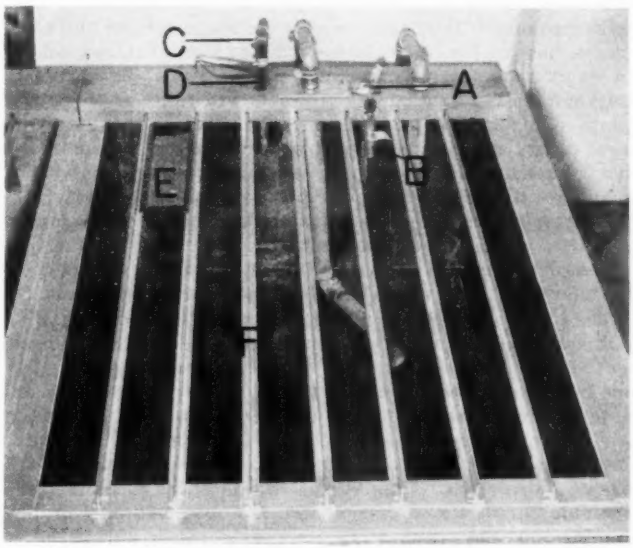

FIGURE 3. View of a single controlled temperature tank. An immersion type heater (A) is controlled by a thermostat (B). Cold water inlet (C), which is controlled by a thermostat (D). Pans (E) are held in place by inverted lengths of Tee-iron (F).

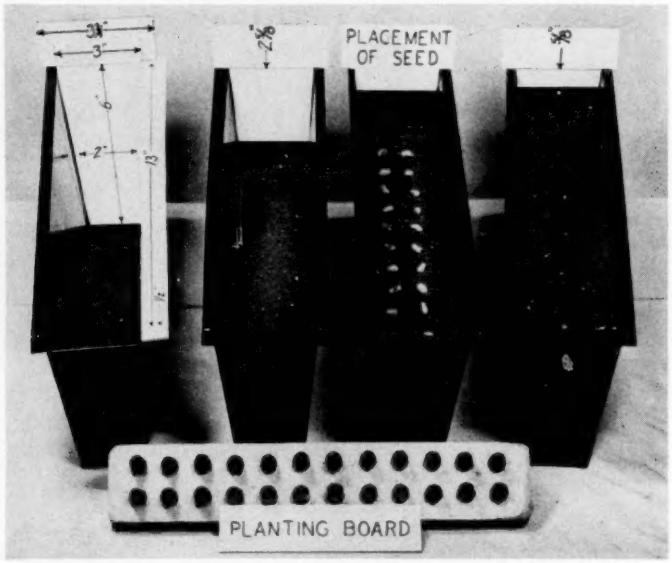

FIGURE 4. Detail and dimensions of pans and illustration of the method used to obtain controlled spacing and depth of seed when planting.

the storage tank to a specific temperature bath. In each controlled temperature tank is a small thermostatically controlled 600-watt immersion type electric water heating unit. In tanks in which the desired temperature is below the ambient room temperature only the cold water thermostat is utilized. Where the desired temperature is above the ambient room temperature only the thermostat controlling the immersion heater operates. In the case of temperatures near the ambient temperature both the cold water and heater thermostats are utilized. By carefully regulating the thermostats an accurately controlled bath can be obtained without over-working either the heater or the cold water pump. Circulation, or agitation, of the water in each tank is accomplished with a small centrifugal pump, mounted on a base separate from the controlled bath, which keeps the water in constant movement and quickly spreads cold or warm water throughout the tank. Initially, a mechanical stirrer was utilized but vibration caused considerable packing of the soil in the pans. The refrigeration unit is mounted on rubber and transmits no noticeable vibration.

Upon completion of the unit, a series of test runs was made. Initially, temperatures of 60°, 65°, 70°, and 75° F were used. Before the pans were inserted, the water in the baths was brought to the desired temperatures. This was accomplished by placing four laboratory thermometers at various positions in a bath and adjusting the thermostats until a constant reading throughout a given tank was maintained. The pans containing soil and seed were then placed in the bath and allowed to rest for 4 hours before starting the test. The soil was then watered and in each bath four laboratory thermometers were placed in the soil of four of the pans at a depth of 2 inches. A careful check was made every 2 hours for a 36-hour period, during which the room temperature varied from 72° F at night to 92° during the day. The diurnal variation of the temperature baths amounted to 1/2 degree Fahrenheit. This variation was noted as a rise in the desired temperature for a 2-hour period during the afternoon and was observed only in the 60° tank. In room temperatures exceeding 100° the present 1/2-ton refrigeration unit is not capable of maintaining bath temperatures of 60° or lower.

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DEPARTMENT OF PLANT PHYSIOLOGY AND PATHOLOGY, TEXAS AGRICULTURAL EXPERIMENT STATION, AND FIELD CROPS RESEARCH BRANCH, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE, COLLEGE STATION, TEXAS

THE EFFECT OF CERTAIN FACTORS ON FORAGE CROP FAILURES IN SOUTHERN ONTARIO[1]

W. G. Benedict[2]

ABSTRACT

The contributions of insects, fungi, and nematodes, and the effect of soil temperature and moisture were studied for one year to determine the causes of forage crop failures on a fine sandy loam. The results of greenhouse and field experiments and the use of standard procedures and measurements showed that the effects of drought at a critical period in the ontogeny of the crop were more important than biological factors.

INTRODUCTION

During recent years in southwestern Ontario there have been failures in first-year stands of clovers on sandy loam soils. Losses have been especially severe in Essex County on Tuscola fine sandy loam in fields which have fair to poor natural drainage and cover 6000 acres. General farming and dairying are carried on in this area but the growing of corn, tobacco and canning crops is an important enterprise in some localities. The purpose of the present studies was to evaluate the contribution of certain factors usually associated with soil-borne diseases of forage crops on sandy loam.

MATERIALS AND METHODS

The soil utilized in both greenhouse and field experiments was Tuscola fine sandy loam from a field which for 3 consecutive years had failed to yield good crops of red clover, other clovers, or forage grasses.

The chemicals specifically chosen to control partially biological groups of organisms were hexachloro-epoxy-octahydro-dimethanonaphthalene (Dieldrin), which is an effective insecticide; pentachloronitrobenzene or PCNB (Brassicol), which is an effective fungicide; dichloropropene-propane (DD mixture), which is an effective nematocide; and sodium N-methyl-dithiocarbamate dihydrate (Vapam), which is an "eradicant" fumigant upon insects, fungi, nematodes and certain weed seeds. All chemicals were used at the rates recommended by the manufacturers.

The forage crops consisted of the legumes sweetclover, alfalfa, red clover, alsike clover, Ladino clover, and bird's-foot trefoil, and the grasses orchard grass, timothy, perennial ryegrass, meadow fescue, redtop, smooth brome, and Kentucky bluegrass.

The experimental designs and the measurements of plant growth and numbers of insects, fungi and nematodes are standard and are described briefly under the appropriate headings of sections which follow.

EXPERIMENTS

In the Greenhouse

On May 24, 1955, seed of the six clovers and seven grasses was sown in separate rows in 48 flats, size 24 x 12 x 4 inches. The 13 rows of different seeds per flat were randomized according to the table of 10,000 randomly assorted digits by Snedecor (2). The six treatments, namely, (a) check, (b) insecticide, (c) fungicide, (d) nematocide, (e) a mixture of the insecticide, fungicide and nematocide, and (f) Vapam, were also randomized and duplicated in four blocks or replications, one half of the soil having been steam-sterilized before treatment with the chemicals. The purpose of steam-sterilizing one half of the soil was to have a check on the effect of the chemicals on the growth of the plants in the absence of soil-borne pathogens. One month after seeding seedlings were thinned to the ten sturdiest plants.

On September 26, 1955, the tops of all plants were cut off at the surface of the soil and weighed. Growth was used as the gauge to evaluate the efficacy of the chemicals to control the

[1] Contribution No. 1539 from the Botany and Plant Pathology Division, Science Service, Canada Department of Agriculture, Ottawa, Ontario.

[2] Associate Plant Pathologist, Science Service Laboratory, Harrow, Ontario.

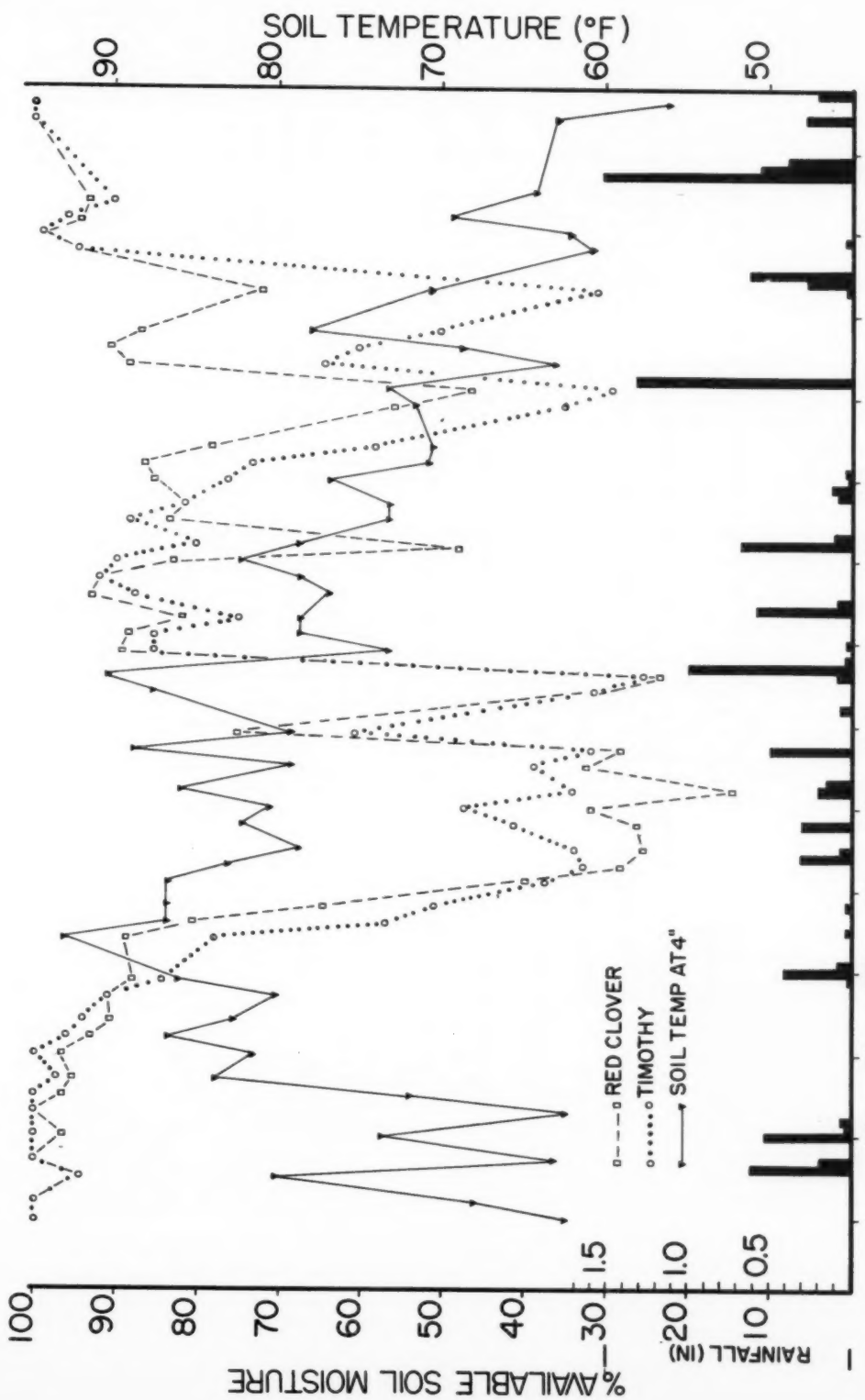

FIGURE 1. AVAILABLE SOIL MOISTURE, SOIL TEMPERATURE, AND PRECIPITATION AT HARROW, FROM JUNE 1 TO OCTOBER 15, 1955, IN THE RED CLOVER AND TIMOTHY PLOTS.

Table 1. Mean dry weight in grams of ten plants of five clovers and seven grasses grown four months in the field in six treatments of field soil.

Treatment	Sweet-clover	Alfalfa	Red clover	Alsike clover	Ladino clover	Orchard grass	Timothy	Perennial ryegrass	Meadow fescue	Red-top	Smooth brome	Kentucky bluegrass
a Check	387.6	259.3	175.5	195.3	478.3	624.9	255.8	452.4	749.1	447.4	553.7	40.1
b Insecticide (Dieldrin)	383.8	234.4	185.1	233.4	508.6	729.4	412.4*	410.8	753.9	522.4	802.7	85.9*
c Fungicide (PCNB)	443.7	275.4	157.4	183.0	490.7	516.9	362.6*	420.5	716.7	401.6	666.1	38.4
d Nematocide (DD)	454.6*	236.2	160.7	257.5	543.6	652.6	349.4	490.5	916.6	453.8	802.4	54.3
e Mixture (b,c,d)	499.1*	291.0	151.6	284.4*	529.6	582.4	380.0*	398.5	832.4	514.9	800.1	83.8*
f Vapam	403.2	300.9	159.4	186.8	556.5	621.6	300.2	487.8	875.8	445.4	751.2	40.4
L.S.D. .01	90.4	123.8	60.0	95.5	186.2	202.7	131.9	218.7	237.7	176.7	379.2	34.4
*L.S.D. .05	66.5	91.1	44.2	71.1	136.9	149.2	97.1	160.9	174.9	130.1	279.1	25.3

specific groups of soil-borne organisms. The mean total weights of the 4-month-old plants were recorded.

A comparison of plant growth in sterilized soil and unsterilized soil showed that alfalfa, bird's-foot trefoil, and Ladino clover grew better in the unsterilized soil, and Kentucky bluegrass grew equally well in the unsterilized and sterilized soil. Other clovers and grasses grew from 16 to 97 percent better in the sterilized soil, the extremes of this range being found, respectively, in red clover and timothy. An analysis of the results of the treatments showed that only bird's-foot trefoil and Ladino clover grew significantly better in soil treated with certain chemicals. Among the grasses and clovers tested here only Ladino clover benefited by treatment of the sterilized soil with the insecticide, the fungicide, the nematocide, and the mixture of all three of them. Growth of Ladino in sterilized soil that had been treated with Vapam was no better than that in the check plot. With the exception just mentioned the chemical treatments and soil sterilization neither stimulated nor retarded growth of the forage plants significantly under the conditions of this experiment.

In the Field

On May 27, 1955, month-old seedlings of five clovers and seven grasses that had been grown in sterilized soil in the greenhouse were transplanted to the field. Ten days previously the field had been divided into plots and subplots according to a Latin Square design, each plot being subdivided into five rows or replications each having subplots of the six treatments. The insecticide and fungicide were each applied at the rate of five pounds of the actual chemical per acre; the nematocide was applied at the rate of 40 Imperial gallons per acre, and the Vapam at 400 pounds (100 U.S. gallons) per acre. Each plot contained 300 plants placed 18 inches apart in the rows, the rows crosswise being 30 inches apart. The plots were kept free of weeds during the growing season.

On September 19, 1955, the tops of each plant were cut off 1 inch from the soil surface, wrapped and labelled, and placed in a dryer kept at 100° F for 1 week. The mean dry weight of the plants was then used as the standard to determine differences in growth of the forage in the treated soil in the field plots. The weights were recorded.

In Table 1, comparison of plant growth according to soil treatment shows that the following plants grew significantly better in treated soil than in untreated soil: timothy and Kentucky bluegrass in the insecticide-treated soil, timothy in the fungicide-treated soil, sweetclover in the nematocide-treated soil, and sweetclover, alsike clover, timothy and Kentucky bluegrass in the "mixture"-treated soil. A comparison of plant growth between treatments shows that alsike clover and meadow fescue grew significantly better in the nematocide-treated soil and orchard grass in the insecticide-treated soil than each of these grew in the fungicide-treated soil. The treated soil did not otherwise produce better growth than the untreated soil in this experiment.

In the Laboratory

At harvest time samples of roots and soil beneath the plants in the field plots were brought into the laboratory to be examined for populations of insects, fungi, and nematodes. Each sample consisted of a complete mixture of one-quarter of the root system along with surrounding soil to a depth of 4 to 6 inches from ten plants in each replication in each block. The soil and roots of each sample were thoroughly mixed and divided into smaller lots for ease in handling.

Insects: By the Berlese funnel method of drying the soil samples the insects were driven out of the soil. From the soil obtained under sweetclover, orchard grass, timothy and perennial ryegrass only a few wireworm larvae in different stages of development emerged. It may be mentioned here that in the field at harvest time mealybugs, Heterococcus sp., were numerous among the leaf bases of the grasses redtop, perennial ryegrass, meadow fescue and smooth brome. Other mealybugs, Pseudococcus maritimus (Ehrh.), were found in considerable numbers on the roots of red and alsike clovers.

Fungi: By direct microscopic examinations of the roots that were washed and stained with acid fuchsin in lactophenol the fungus rating of the five clovers and seven grasses was obtained. In general, the hosts that appeared to carry the largest fungus populations were Kentucky bluegrass, red clover, and alfalfa, while those carrying the least fungi were timothy, redtop, and

orchard grass. When the total fungi according to treatment are compared the roots in Vapam-treated soil contained the fewest fungi.

Nematodes: By the Baermann funnel technique and direct microscopic examination the nematodes found in the roots of the clovers and grasses were determined. Representatives of the genus Pratylenchus, the root lesion nematode, were the only endoparasites present. Occasionally ectoparasitic forms of Rotylenchus, the spiral nematode, and Xiphinema, the needle nematode, were found.

The most favorable hosts for Pratylenchus appeared to be red clover, orchard grass, timothy, and Kentucky bluegrass. The least favorable hosts were sweetclover, alfalfa, and smooth brome. Saprophytic nematodes were numerous in necrotic tissues of sweetclover, red clover, and alsike clover roots but were absent from roots of alfalfa and the grasses. The wide fluctuation in populations of the nematodes was thought to be due to a very uneven distribution of the parasites throughout the field plots.

MEASUREMENT OF SOIL MOISTURE

By means of a conductivity-bridge apparatus, the method of Bouyoucos and Mick (1), readings of the soil moisture in the field at a depth of 4 inches under certain clovers and grasses were taken three times weekly throughout the growing season. The observed resistances recorded by the apparatus were corrected to a constant temperature at 73° F by the slide rule method and the results charted in Figure 1. Records of the temperature and rainfall are included in the chart. Figure 1 shows the available soil moisture under red clover and timothy from the time that the seedlings were set in the field plots in the spring until after the forage was harvested in the fall.

Of special interest in Figure 1 is a period of 52 days from June 16 until August 7 when the soil temperature was above 78° F, at one time reaching 96.5° at a depth of 4 inches below the surface. Immediately following this peak in soil temperature the available soil moisture dropped sharply from 88 percent to 28 percent and remained below 35 percent under red clover for a period of 15 days. During this time a low soil moisture reading of 14.3 percent was reached.

DISCUSSION AND CONCLUSIONS

Since forage crop failures were predominant in the sandy loam soils of southwestern Ontario it was postulated that some factor peculiar to the soil type was responsible. Inasmuch as the cause of the poor crops was obscure, this factor was assumed to be a biological one circumscribed by the effect it had upon the crop through the root system.

Because of the capacity of the complex natural microflora and microfauna of the soil for resisting changes, the difficulty of direct economical control of soilborne diseases in the field by means of chemical substances was recognized. For this reason it was thought that the use of chemicals which were effective against insects, fungi, or nematodes would probably reduce populations of specific groups of organisms and permit the unbalanced bionomics to counteract the effect of the crop failure.

However, in the present study, the insect population of the untreated soil was extremely low in the root zone, the fungi found were almost certainly secondary parasites or saprophytes, and the populations of nematodes were extremely variable. These findings and the slight, if any, differences in the results between the greenhouse and the field experiments showed that, in this study, the injurious effects of certain groups of organisms upon the forage crops were insignificant.

A more thorough experimental approach to the microbial ecology might reveal competitive and associative effects of the soil-inhabiting microorganims, but the results of the present study indicate that a period of drought was of more consequence in the crop failures than the effect of insects, fungi, and nematodes upon the forage crop plants growing locally on sandy loam.

ACKNOWLEDGMENTS

The author is indebted to H. R. Boyce and W. B. Mountain, Science Service Laboratory, Harrow, for the identification of the insects and the nematodes, respectively.

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SCIENCE SERVICE LABORATORY, HARROW, ONTARIO

CAUSES AND CONTROL OF ROOT ROT IN MICHIGAN GREENHOUSES[1]

R. P. Scheffer and W. J. Haney

SUMMARY

The pathogens most often isolated from Croft lily, poinsettia, and other plants with root rot were Rhizoctonia solani and Pythium ultimum. The latter fungus from Croft lilies was pathogenic to Lilium pumilum seedlings, L. longiflorum var. Georgia, poinsettia, sweetpea, and several other plants. Pythium from poinsettia appeared to be identical with Pythium from Croft lily. Evidence indicates that both R. solani and Pythium spp. are introduced into greenhouses with field-grown bulbs. Many bulb and soil treatments were tried without success on Croft lilies. No chemical treatments were as satisfactory as was soil steaming for poinsettia production. Seed germination assays showed that pentachloronitrobenzene controlled R. solani and had good residual properties, but was without effect on P. ultimum. Captan used as a soil mixture at high concentrations inhibited both fungi, but had poor residual properties. Certain pyridinethione derivatives were effective and were fairly stable in the soil.

During recent years root rot has become one of the principal diseases affecting greenhouse flower production in Michigan. Plants most often observed with severe root rot have been Easter lilies and poinsettias, but similar trouble was seen from time to time on rubrum, auratum and calla lily, geranium, azalea, hydrangea, tulip, daffodil, hyacinth, sweetpea, snapdragon, rose, petunia, calceolaria, cineraria, African violet, gloxinia, coleus, begonia, and chrysanthemum. In fact, the trouble is so common in some greenhouses that improper cultural practices are blamed directly. In the present work an effort was made to determine the pathogens of importance under Michigan conditions.

Ornamental crops are attacked by a variety of root-rot fungi (4, 7, 8, 10) which generally are controlled in the greenhouse by soil steaming (pasteurization) and thorough sanitation. There are certain situations in greenhouse production, such as forcing field-grown bulbs, for which these measures do not apply, and such situations often result in serious losses. Chemical treatments offer a possible solution to such problems.

In the past, fungicidal treatment of soil for root rot control generally has given poor results. Some newer materials, however, give hope that soil fungicides eventually will be effective. Pentachloronitrobenzene (PCNB), for example, is effective against certain soil pathogens (3, 5) and appears to have good residual qualities in the soil. Such materials may prove useful in controlling some diseases of greenhouse crops which are not adequately controlled by soil pasteurization. Several experimental and commercially available materials were screened for possible use against specific root rot pathogens.

CAUSES OF ROOT ROT IN MICHIGAN GREENHOUSES

Microscopic examination of roots of Croft lily (Lilium longiflorum var. Croft) and poinsettia plants from several greenhouses usually showed a Phycomycete in newly rotted portions. In addition, hyphal strands of a fungus with Rhizoctonia-like branching was often found in such roots. Badly rotted tissue contained many types of fungi.

Standard procedures using agar media were used to isolate microorganisms from diseased roots. The fungus most often isolated from lilies and poinsettias was Pythium ultimum Trow (identified by E. S. Beneke and R. P. Collins), which was found in material from many greenhouses in southern Michigan. The next most common fungus was Rhizoctonia solani Kuehn; this species was isolated from lesions on the lower stems as well as from roots. Other fungi included species of Fusarium, Chaetomium, Hormodendron, Penicillium, Alternaria, Mucor, Trichoderma, Phytophthora, and Phoma. Isolations from other hosts gave similar fungi. When carrot slices were used (11) Thielaviopsis usually was found if plants had been grown in unsteamed soil.

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[1] This work was supported in part by funds from the Southeastern Michigan Florist's Association. The assistance of W. O. McCartney and R. P. Collins is gratefully acknowledged. Photographs were taken by P. G. Coleman. Mighican Agricultural Experiment Station Journal Article 1910.

FIGURE 1. Effect of Pythium ultimum on roots of Georgia lilies grown in pasteurized soil. Left, inoculated plant; right, uninoculated control.

FIGURE 2. Effect of Pythium ultimum on poinsettia plants grown in pasteurized soil. Left and center, uninoculated controls; right, inoculated.

Table 1. Treatments used on Croft lilies for possible root rot control.

Material	How Used	Soil	Dates
	Naturally Infected Bulbs		
Copper-8-quinolinolate	A. Bulb dip-250 p.p.m. sol.	Unsteamed	12/17/53
	B. Bulb dip - soil drench[a] 250 p.p.m. sol.	Unsteamed	12/17/53
	C. Bulb dip - 1250 p.p.m. sol.	Steamed	12/17/53
Oxyquinoline sulfate	Soil mixes-0.396, 198, 3.96 g.[b]	Unsteamed	3/1/54
Formalin	30 min. bulb soak in 2.0% sol.	Steamed	12/17/53
Nabam	Soil drench-1000 p.p.m. sol.	Steamed	12/17/53
Thiram 50% dust	Mixed 1:2 with talc. Bulbs dusted	Steamed	12/17/53
Dowcide A	4 hr. bulb soak in 50 p.p.m. sol.	Steamed	12/17/53
Lysol-Ferbam	30 min. bulb soak in 2 ox. Ferbam,	Steamed vs.	3/1/54
	1/2 pt. Lysol, 6 gals. water	Unsteamed	12/15/55
Hot water 110° F.	Bulb soak for 3.5 hrs.	Steamed	12/17/53
Systox	Soil drench	Steamed	12/17/53
Actidione	A. 60 min. bulb soak-100 p.p.m.	Unsteamed	3/12/53
	B. Bulb soak, 100 p.p.m. + soil drench, 10 p.p.m.	Unsteamed	3/12/53
Panogen	A. Soil drench-100 p.p.m. sol.	Unsteamed	3/1/54
	B. Bulb dip + soil drench 100 p.p.m. sol.	Steamed	3/1/54
Ziram	A. Soil mixes - 0.396, 198. 3.96 g.	Unsteamed	3/1/54
	B. Soil mix-1.98 g.	Steamed	7/8/54
PCNB, 20% dust	Soil mixes - 0.396, 1.98, 3.96 g.	Unsteamed	3/1/54
PCNB, 75% W. P.	A. Soil mix 1.98 g.	Steamed vs.	7/8/54
	B. Bulb dip 1000 p.p.m. (active material) sol.	Unsteamed	12/15/55
Spergon	A. Soil mixes-0.396, 1.98, 3.96 g.	Steamed	3/1/54
	B. One min. bulb dip-2500 p.p.m. sol.	Steamed	12/17/53
Phygon	Soil mixes-0.396, 1.98, 3.96 g.	Unsteamed	3/1/54
Orthocide 406	Soil mixes-0.396, 1.98, 3.96 g.	Steamed vs.	3/1/54
		Unsteamed	7/8/54
Dinitro Capryl Phenyl Crotonate	Soil mixes-0.396, 0.792, 1.584 g.	"	3/1/54
Stauffer N-521	Soil drench-200 p.p.m. sol.	Steamed vs.	7/8/54
		Unsteamed	
Vancide 51	Bulb dip-1000 p.p.m. sol. + soil drench 2000 p.p.m.	"	7/8/54
Zineb	Soil mix-1.98 g.	"	7/8/54
	Bulbs Inoculated With Pythium ultimum		
Orthocide 406	A. Soil mixes-0.099, 0.198, 0.396, 0.71 g.	Steamed	1/7/55
	B. Soil mix-0.396 g.	Steamed vs. Unsteamed	12/21/54
PCNB 20% dust	Soil mix-0.396 g.	"	12/21/54
Mathieson 1194, 50% W. P.	Soil mix-0.396 g.	"	12/21/54
PCNB (20%) + Orthocide 406	Soil mix-0.396 g. (each)	"	12/21/54
PCNB (20%) + Mathieson 1197	Soil mix - 0.396 g. (each)	Steamed vs. Unsteamed	12/21/54
Mathieson 1197, 50% W.P.	A. Soil mix-0.396 g.	"	12/21/54
	B. Soil mixes-0.099, 0.198, 0.396, 0.792 g	Steamed	12/30/54

[a]All soil drenches were applied weekly.
[b]All soil mix concentrations were in grams of total material per 5 inch pot.

Table 2. Effect of several concentrations of pentachloronitrobenzene, 20 per cent dust used as a soil mix, on development of pythium root rot in inoculated Georgia lilies.

g. per 5 in. pot	g. per cu. ft. of soil	av. root rot index[a, b]
0 (inoculated control	0	4.8
0.198	6.31	5.0
0.396	12.62	4.8
0.792	25.24	4.9
1.188	37.86	5.0
1.980	63.10	4.9
0 (uninoculated control)	0	0.8
L.S.D. .05	--	1.4

[a] Disease index estimated visually on a 0 - 5 scale, with 0 = no root rot, 5 = all roots dead.

[b] Average values for 12 plants (4 replications, 3 plants per replication).

Representative fungus isolates from lily and poinsettia were tested for pathogenicity in soil. A good potting soil consisting of a mixture of loam, peat and sand was carefully steam-pasteurized in 4- or 5-inch pots, and arrangements were made to eliminate cross contamination by pot-to-pot splash or by drainage. Inoculum was grown in a moist sterile mixture of sand or vermiculite and corn meal. After good growth had occurred, a piece of inoculum approximately 15 mm. in diameter was placed in each pot of steamed soil, approximately 5 cm. from the bottom. Inoculum was buried, and seeds or plants were set in each pot. At various times Lilium pumilum seedlings, poinsettia plants, and African violet plants were transplanted into such soil to test pathogenicity of fungus isolates. More frequently, sweetpea were used. Sweetpea was a convenient test plant, and should give a valid assay because Pythium and Rhizoctonia species usually are not host-specific. Croft lily bulbs were not used for pathogenicity tests because disease-free bulbs are difficult to find.

Many Pythium isolates caused root rot, stunting, leaf yellowing, leaf drop, and general unthriftiness in L. pumilum and poinsettia plants. Pythium isolates from lily were, in all cases tried, pathogenic to poinsettia and the fungus was re-isolated from test plants. Only one Pythium isolate from poinsettia was tested against lily; it was highly virulent to L. pumilum seedlings. Rhizoctonia isolates were pathogenic to sweetpea and to poinsettia, but have not been tested against other hosts; according to Tolba and Moubasher (9), a wide host range is expected. Both Pythium and Rhizoctonia from lily roots were capable of causing seedling damp-off in many plants besides sweetpea. One Phytophthora isolate was pathogenic to both African violet and sweetpea, but was not tested against other hosts. Isolates of other fungi were tested only on sweetpea; all were non-pathogenic. Several Thielaviopsis isolates were tested on sweetpea and poinsettia with negative results. However, an intensive search for pathogenic strains of this fungus was not made. Other workers have isolated pathogenic strains of Thielaviopsis from poinsettia (4).

Several lots of lily bulbs obtained directly from commercial sources were grown under conditions precluding contamination by fungi from a local source. Root rot always developed in such plants, and in several cases pathogenic strains of Pythium and Rhizoctonia were isolated from diseased areas. No examination was made to determine the frequency of such occurrence, but it is apparent that pathogens can be introduced into greenhouse beds or benches in this way.

Table 3. Effect of soil treatments on root rot development in poinsettia inoculated with Pythium ultimum.

Treatment	Disease index 4 weeks after inoculation[a, b]		Disease index 19 weeks after inoc.	
	steamed soil	unsteamed soil	steamed soil	unsteamed soil
Nabam - weekly drench with 1000 p.p.m.	2.0	1.8		
Copper - 8 - quinolinolate weekly drench-1000 p.p.m.	2.4	2.6		
Stauffer N-521 weekly drench 200 p.p.m.	3.8	4.0		
Panogen-weekly drench 100 p.p.m.	2.2	3.0		
PCNB (20% dust) soil mix -1.98 g./5" pot	2.4	1.9		
Orthocide 406 Soil mix -1.98 g./5" pot	1.0	0.5	3.0	2.7
Inoculated Control	2.4	3.3	5.0	4.3
Uninoculated Control	0	0	0	0
L.S.D. .05	0.8			

[a] Disease index estimated visually on a 0 - 5 scale, with 0 = no root rot, 5 = all roots dead.

[b] Average values for 12 plants (3 replications, 4 plants per replication).

EXPERIMENTS WITH SOIL FUNGICIDES

On Lilies

Croft lilies forced in the greenhouse for the Easter market almost always are affected to some extent by root rot, regardless of the sanitation practices of the grower. Root rot fungi apparently come with bulbs from field producers. Two possibilities for control are evident: a source of disease-free bulbs may be found, or fungicides for bulb and soil treatments may be developed. From the short-range view the latter possibility may be easier.

A number of soil and bulb treatments (Table 1) were used on Croft lilies for possible root rot control. The materials were used in randomized, replicated experiments with plants growing in 5-inch pots. In some experiments each pot was infested with Pythium, as described above, to insure uniform infection. In other experiments natural infection, which always was adequate, was relied upon. Both steam-pasteurized and unsteamed soils were used in various experiments (Table 1). Fungicides were used as bulb dips, soil treatments, or both, as specified in Table 1. Soil treatments were either drenches with the fungicide in solution or suspension, or the fungicide was mixed with the soil as a dry powder prior to planting.

Results of these experiments have all been negative, thus the data are not given in more detail. Such results could mean that the pathogens are not affected by the fungicides, or are merely suppressed until the fungicides are inactivated in the soil. However, negative results

Table 4. Residual effects of soil fungicides for control of Rhizoctonia solani, using sweetpea as the test plant.

Treatment [a]	Stand counts [b] for successive plantings			
	12/31/54 [c]	2/2/55	3/21/55	5/13/55
Orthocide 406	26.5	28.3	2.3	5.0
PCNB 20% dust	24.5	25.8	23.8	27.0
Mathieson 1197, 50% W. P.	0.7	25.8	0	1.0
Mathieson 1194, 50% W. P.	21.7	23.3	20.5	18.8
PCNB + Orthocide 406	23.3	22.8	24.5	26.5
PCNB + Mathieson 1194	16.0	25.3	25.3	27.3
PCNB + Mathieson 1197	4.3	25.8	23.5	26.8
Inoculated control	4.8	2.0	0.8	0
Uninoculated control	24.0	28.5	27.0	28.0
L.S.D. .05	4.3	4.8	3.0	3.8

[a] All materials mixed with soil at the rate of 0.396 g. of total material per 5-inch pot (12.62 g. per cu. ft. of soil, equivalent to 400 lbs. per acre).
[b] Average germination per replication. There were 4 replications, 3 pots per replication, and 10 seeds per pot.
[c] Planting dates. Stand counts were taken 2 to 4 weeks later.

with PCNB (supplied by the Olin Mathieson Corporation) indicate that Rhizoctonia was not an important factor in these experiments, since this fungus is controlled effectively by PCNB (see below). On the other hand, Pythium spp. are known to be highly resistant to many chemicals in the soil. This statement was supported by an experiment with Georgia lilies (L. longiflorum var. Georgia) which gave no evidence of carrying harmful soil fungi. Steamed soil in 5-inch pots was treated with PCNB at the rates of 6.31, 12.62, 25.24, 37.86, and 63.1 gm. per cubic foot of soil (200, 400, 800, 1200, 2000 pounds per acre, equivalent), and the soil was infested with P. ultimum. This fungus was pathogenic to Georgia lily (Fig. 1) and was re-isolated from diseased roots. Results (Table 2) showed that PCNB was without effect on Pythium root rot development. The very slight root rot in the uninoculated checks probably was normal dying of roots as they became senescent.

On Poinsettia

Several soil treatments using poinsettia as a test plant were used in three experiments. Rooted cuttings were set in 3-inch pots of treated soil and when they recovered from transplanting each pot was infested with Pythium ultimum. Randomized, replicated experiments were used with the appropriate untreated inoculated and untreated uninoculated controls. Data from a typical experiment are given in Table 3. Of all the materials used, only Orthocide 406 used as a soil mix gave any control of Pythium (Table 3). However, 63.1 gms. of total material per cubic foot of soil (equivalent to 2000 pounds per acre), a very heavy application, was required for disease control. This concentration in a later experiment caused injury to plants. Also, the effect was short-lived, most of the protection being lost sometime after the fourth week (Table 3). Lower levels (equivalent to 200, 400, and 800 pounds per acre) gave no control, nor did a weekly drench with Captan 50W. Ineffectiveness of the captan drench agrees with results reported by Kendrick et al. (5). All plants in steam-pasteurized soil were completely free from root rot (Table 3, Fig. 2).

Table 5. Residual effects of soil fungicides for control of Pythium ultimum, using sweetpea as the test plant.

Treatment [a]	Stand counts [b] for successive plantings		
	12/9/54 [c]	1/13/55	3/14/55
Orthocide 406	21.3	8.5	1.5
PCNB 20% dust	0.8	0.7	0.8
Mathieson 1197, 50% W. P.	5.5	8.3	0.5
Mathieson 1194, 50% W. P.	9.3	0	0.8
PCNB + Orthocide 406	22.5	12.3	3.0
PCNB + Mathieson 1197	7.5	8.3	1.3
Inoculated control	0.8	0	0.5
Uninoculated control	21.0	19.5	11.0
L.S.D. .05	5.0	7.3	--

[a] All materials mixed with soil at rate of 0.396 g. of total material per 5-inch pot, or 12.62 g. per cu. ft.

[b] Average germination per replication. There were 3 replications, 3 pots per replication, and 10 seeds per pot.

[c] Planting dates. Stand counts were taken 10 to 28 days later.

Residual Effects of Fungicides in Soil

Several materials used as soil mixes were tested for lasting effect in the soil and for specific effectiveness against Rhizoctonia solani and Pythium ultimum. The compound to be tested was mixed thoroughly with measured amounts of carefully steam-pasteurized potting soil (2 parts loam, 1 part peat, 1 part sand). Previously steamed 4- or 5-inch pots were placed within raised 7-inch pots to prevent pot-to-pot splash. A small piece of inoculum, grown on vermiculite-corn meal medium, was placed in each pot and covered with soil, and 10 sweetpea seeds were planted per pot. Theoretically, if an effective fungicide were present the fungus would never reach the seed, but if no protectant were present soil pathogens should quickly invade steamed soil and attack germinating seed.

Data were taken as stand counts 2 to 4 weeks after planting, and as fresh weights of plants. Since the two sets of data showed the same results, only the former is reported. To determine residual effects, successive crops of sweetpeas were planted in the same soil, with fresh inoculum supplied for each crop. Randomized, replicated experiments and analysis of variance were used.

In an experiment summarized in Table 4 several materials gave positive control of R. solani. The outstanding fungicide was PCNB, which allowed good seed germination and growth throughout the 24-week experiment. Orthocide 406 gave good initial protection, but was inactivated between the fifth and eleventh week. This data agrees with results obtained with poinsettia, where protection from captan was soon lost. Mathieson Compound 1194 gave moderate protection, but caused stunting of seedlings, as determined by green weights. Mathieson 1197 was severely phytotoxic at first, slightly toxic the second planting, then lost its fungicidal value (Table 4). Several combinations of materials were without additive effects.

In contrast to R. solani, P. ultimum was not affected by PCNB. Of all the materials tested in an experiment summarized in Table 5, only Orthocide 406 gave control, and this protection was lost before the fifth week of the experiment. Poor showings of materials listed in Table 5

Table 6 Residual effects of Mathieson experimental compounds used as soil mixes for control of Pythium ultimum, with sweet pea as the test plant.

Material and Concentration [a]	Stand counts for successive plantings [b]			
	7/7/55 [c]	7/27/55	9/5/55	10/3/55
#1563 (zinc mercaptopyridine oxide)				
1.58	9.7	13.0	2.0	
6.31	20.7	13.7	1.3	
13.76	27.7	29.3	2.0	
#1456 (2-pyridinethione 1-oxide, disulfide derivative)				
1.58	3.3	16.0	2.3	
4.58	13.0	17.7	3.0	
20.10	21.7	22.3	4.0	
#1562 (Copperhydroxypyridinethione)				
1.58	17.3	17.7	2.0	
6.31	22.7	20.3	16.7	7.7
13.76	23.7	28.7	21.0	13.7
#1564 (Manganese mercaptopyridine oxide)				
1.58	9.0	12.3	3.0	
6.31	9.0	11.0	4.3	
13.76	18.3	26.0	2.3	
#1589 (1-thiocyano - 2,4 dinitrobenzene)				
1 58	8.3	7.0	1.3	
13.76	20.0	7.7	1.3	
41.28	12.3	20.7	1.0	
Inoculated control	6.0	5.7	1.0	1.5
Uninoculated control	28.3	21.3	25.7	17.8
L.S.D. .05	6.7	6.3	6.7	

[a] All concentrations are given in grams of active material per cu. ft. of soil.

[b] Average no. of seeds germinating per replication. There were 3 replications, 3 pots per replication, 10 seeds per pot.

[c] Planting dates. Stand counts were taken 10 to 28 days later.

led to test of a series of experimental pyridinethione derivatives and compound 1589, all supplied by the Olin Mathieson Chemical Corporation. These compounds, listed in Table 6, were first tested for possible phytotoxic effects at 1.58 and 6.31 gms. per cubic foot of soil. The disulfide derivative and M-1589 caused stunting at the higher concentration, but the other materials were not phytotoxic. All gave protection against P. ultimum in the soil (Table 6), with zinc and copper salts of pyridinethione performing best. Only the copper salt was still active after the eighth week, an effect which may be attributed to the compound per se, or to a residual copper effect. At any rate, this material is to be tested further.

DISCUSSION

Causes of root-rot of Croft lilies in the greenhouse have not been determined with certainty because disease-free bulbs have not been available for pathogenicity tests. Rhizoctonia solani has been suggested as a pathogen (1), but negative results with PCNB, which is very effective against this fungus, indicate that other fungi are at least as important. Two kinds of circumstantial evidence indicate that Fusarium spp. are not important. First, our experiments were in most cases run at 55° and 60° F. night temperatures, well below the optimum for known Fusaria. Also, several materials known to be effective against Fusaria (5) were used in the tests without affecting root-rot development. Frequent observation of Phycomycetes in rotted roots, frequent isolation of Pythium ultimum, and proved pathogenicity to Lilium pumilum seedlings, L. longiflorum var. Georgia (Fig. 1), poinsettia (Fig. 2), sweetpea, and other plants, shows that Pythium is a pathogen of importance under Michigan conditions. Concurrent infection by Pythium and Rhizoctonia is indicated.

Root rot fungi appear to be coming with bulbs from field producers. This is generally accepted by workers who have studied the problem (1), and is borne out by our observations. In several instances both Pythium and Rhizoctonia solani were isolated from Croft lily bulbs grown under conditions precluding infection after bulbs were obtained. Very likely these pathogens do no damage under field conditions, but under the different soil, temperature, light, moisture, and aeration conditions of the forcing greenhouse, they become serious problems.

Poinsettia is attacked by several soil fungi, including Thielaviopsis basicola (4), Rhizoctonia solani, and Pythium ultimum. Undoubtedly, all of these occur in Michigan greenhouses, since they can all be isolated from unpasteurized soils. However, T. basicola is host-specific (4), and strains pathogenic to poinsettia are not expected in most soils. Our opinion is that T. basicola pathogenic to poinsettia is ordinarily found only on poinsettia stock plants which are all shipped from a common source. If a grower separates stock plants from propagating and growing benches, T. basicola should give no trouble, since it is not systemic and is not carried with cuttings. Since R. solani and Pythium are generally not host-specific, and can be brought into greenhouses with bulbs, plants, or unsteamed soil, they appear to present greater problems. This opinion is based on observations and isolations of fungi from plants from greenhouses in southern Michigan.

Root rot control by a grower requires some understanding of the means of dissemination of the pathogens. If soil in a bench becomes infested, these fungi, being also efficient saprophytes, remain indefinitely, infecting successive crops planted in the bench or beds, or infesting pots placed on the soil. Most soil pathogens can grow rapidly through steamed soil, and can be splashed from pot to pot by careless watering. If a grower uses pond water, pathogenic Phycomycetes such as Pythium or Phytophthora can be re-introduced continually (2).

The most practical greenhouse control of root rot in plants propagated by seed or by cuttings is thorough steam pasteurization of soil plus rigid sanitation. This practice is especially important after a bulb crop has been grown. The most common fault is probably the lack of thoroughness, since long steaming is required where the soil is several inches deep in a bed or bench. Growers have been known to steam soil thoroughly, then place it in unsteamed pots, or place the potted plants on soil in unsteamed benches. Fumigation or other chemical treatments of soils prior to planting, though less satisfactory than steam, is available to producers without steam equipment (6).

Although steam pasteurization will control root rot in plants propagated by seed or by cuttings, there is still the problem of control in bulbs and rooted plants brought into the greenhouse for forcing. Possibility of control here rests with use of disease-free stocks, which may be a long-time project, or with the use of fungicides on bulbs or in the soil. Such treatment would find immediate use if effective materials with good residual properties could be found. For control of Rhizoctonia we have such a fungicide in PCNB, but species of Pythium are resistant to this and to other soil fungicides. Certain pyridinethione derivitives offer some hope,

but these compounds are not yet available commercially.

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DEPARTMENT OF BOTANY AND PLANT PATHOLOGY AND DEPARTMENT OF HORTICULTURE, MICHIGAN STATE UNIVERSITY, EAST LANSING

THE OCCURRENCE OF ASH RUST IN WESTERN NOVA SCOTIA[1]

D. W. Creelman[2]

Severe and widespread damage to white ash (Fraxinus americana L.) has been caused annually since 1951 by ash rust (Puccinia sparganioides Ell. & Barth.) in the western counties of Nova Scotia. Black ash (Fraxinus nigra Marsh) has been affected to a lesser extent. A survey of available records shows that before 1951 the occurrence of the disease had been sporadic in this area, having been reported in 1932, 1938, 1939 (2), and 1948 (3). These reports are concerned with light and scattered infections. The first severe outbreak was recorded in Kings County in 1951 (2). By 1954 the disease was epiphytotic in six additional counties.

Infection occurs on the ash at any place on the current season's growth. Pycnia were observed on June 10, 1952, on the upper surface of the leaves and on stems and petioles. Aecia were abundant 10 days to 2 weeks later, occurring as conspicuous bright orange pustules on the lower leaf surface and other plant parts. Where they occurred on the leaf blade the groups of aecia tended to remain small in area. Where they occurred on leaf veins, petioles, and young woody growth, the aecial clusters covered an area up to 3 cm. in diameter, and were accompanied by considerable hypertrophy and distortion of the affected host organ. By July 1, the leaves of affected trees appeared wilted and were beginning to turn brown, and by mid-July the trees took on a scorched appearance. Defoliation was well advanced by the beginning of August.

In 1954 it was noted that trees which had been heavily infected during two or more successive seasons were dying. Limbs located at the tops of the trees failed to put forth any leaves. Some small trees had been completely killed. It is assumed that these trees were winter killed after having been considerably weakened from the effects of the rust.

The alternate hosts of ash rust are found in the genus Spartina. Three species occur in abundance in western Nova Scotia. S. patens (Ait.) Muhl. and S. alterniflora Loisel are conspicuous components of the salt marsh flora. S. pectinata Link is not restricted to saline soils and is common throughout the area wherever open ditches, streams and sloughs occur. Teliospores of P. sparganioides have been collected in April on S. patens and S. pectinata. S. alterniflora, listed by Arthur (1) as a host for this rust has not been found infected here. This grass colonizes the intertidal zone and is subjected to complete or partial submergence in salt water at every tide. This condition would explain its escape from infection.

Little is known of the epidemiology of this rust, and hence no satisfactory explanation can be offered for its sudden increase in intensity in 1951, nor for its continuing at a high level of incidence, especially in light of its sporadic occurrence prior to 1951.

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PLANT PATHOLOGY LABORATORY, KENTVILLE, NOVA SCOTIA

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[1] Contribution No. 1529 from the Botany and Plant Pathology Division, Science Service, Canada Department of Agriculture, Ottawa, Ontario.

[2] Assistant Plant Pathologist.

NOTE ON THE SUSCEPTIBILITY OF INDIAN PAINTBRUSH TO CRONARTIUM FILAMENTOSUM[1]

Frank G. Hawksworth[2]

Abstract

The possibility of heteroecism of the important ponderosa pine rust Cronartium filamentosum has not been confirmed in existing literature. Preliminary inoculation tests to clarify this point showed that at least one species of Indian paintbrush (Castilleja austromontana) is susceptible to the rust. Further aeciospore inoculations with other species of Castilleja are planned and sporidial inoculations of pine will be attempted.

The rust fungus Cronartium filamentosum (Peck) Hedgc., is an important and widespread pathogen that attacks the Rocky Mountain form of ponderosa pine, Pinus ponderosa Laws. The only published report on an alternate host for this rust is a note by Hedgcock (4) recording the successful infection of Castilleja sp. However, Arthur and Kern (2) express doubt over these findings because their examination of Hedgcock's aecial material led them to question that the rust used was C. filamentosum. Mielke (6), in recent studies on C. filamentosum did not find the rust on suspected alternate hosts and suggested that it might be able to spread directly from pine to pine. The recent finding of the pycnial stage of C. filamentosum (3) suggests that the fungus might be at least facultatively heteroecious.

In 1952 a Cronartium on Castilleja lineariafolia Benth. at Grand Canyon National Park, Arizona, was found to be associated with ponderosa pines bearing the aecial stage of C. filamentosum. The intensity of infection on Castilleja was directly correlated with proximity to infected ponderosa pine; paintbrush plants within a few feet of infected pines were heavily infected. This was particularly noticeable in sapling and polesized pines. Species of Castilleja have also been recorded as hosts for other species of Cronartium (1). However, the ponderosa pine stands at Grand Canyon were examined thoroughly during an intensive dwarfmistletoe control project, and C. filamentosum was the only species of Cronartium seen in the area. Subsequent observations at Grand Canyon and at several other localities in Arizona and New Mexico revealed that rust infections on Castilleja were often found in the vicinity of C. filamentosum-infected ponderosa pine.

This note records the successful infection of Castilleja austromontana Standl. & Blumer with C. filamentosum in 1955 (Table 1). C. linearifolia was not tested because of poor development of this species in 1955.

The Castilleja plants used were transplanted from the Manzano Mountains near Albuquerque and kept in No. 10 cans throughout the period of study. The inoculum came from the Santa Fe National Forest, New Mexico. The inoculation chamber used was the iceless refrigerator type (5), which was kept moist by running water over the muslin covering. Plants to be inoculated were first saturated with a water spray, then aeciospores were dusted over them. These plants were kept in the chamber for about 70 hours. Check plants were given identical treatment except that aeciospores were not applied. About one-third of the plants died before the conclusion of the experiment. Many others that survived lost a high proportion of their leaves.

A brief description of the uredinial and telial spore stages from the present artificial inoculations follows:

II: Uredinia hypophyllous or amphigenous, erumpent 0.1-0.3 mm. across, orange. Urediniospores: globose to ellipsoid, 11.5 x 15.0 µ.

III: Telia hypophyllous or amphigenous, cylindrical, 50 to 60 µ thick, 0.5-1.0 mm. long, curved, brown. Teliospores oblong, obtuse, 9.0 by 29.0 µ. Sporidia not observed.

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[1] Dr. Howard J. Dittmer, Biology Department, University of New Mexico, Albuquerque, identified the species of Castilleja used in this study and made space available in the University's greenhouse for the inoculation work. His contribution is gratefully acknowledged.

[2] Plant Pathologist, Rocky Mountain Forest and Range Experiment Station, United States Department of Agriculture, Forest Service, with central headquarters at Fort Collins, Colorado, in cooperation with Colorado A&M College.

Table 1. Results of inoculation of Castilleja austromontana with aeciospores of Cronartium filamentosum.

Treatment	Plants in each treatment June 14, 1955	Condition of plants after 8 weeks		
		Plants still living	Plants infected (Uredia and Telia)	
	(No.)	(No.)	(No.)	(Percent)
Inoculated	17	11	4[a]	36
Check	11	7	0	0

[a] Two of the plants successfully inoculated were heavily infected (all leaves infected) while the other 2 were only lightly infected (1 to 2 infected leaves per plant). Specimens from these plants have been filed along with collections of the aecial material used for inoculum as Albuquerque Forest Insect and Disease Laboratory Herbarium Collection No. 98559.

Although C. filamentosum sporidial inoculations of ponderosa pine, which were begun in 1952, have not yet been successful, the available evidence suggests that species of Castilleja are the alternate hosts of this rust and also that they are important in the distribution and intensity of this disease of ponderosa pine.

Further aeciospore inoculation work is planned with other species of Castilleja. Sporidial inoculations of pine will be continued and possibly aeciospore infection of pine will be attempted.

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DIVISION OF FOREST DISEASE RESEARCH, ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION, ALBUQUERQUE, NEW MEXICO

UNUSUAL RECORDS

VERTICILLIUM WILT OF EGGPLANT IN SOUTH FLORIDA

By R. S. Cox

A wilt disease of eggplant has been observed on the organic and adjacent mineral soils of south Florida during the past two years (1954-1955). Laboratory isolations and greenhouse pathogenicity trials established Verticillium albo-atrum Reinke & Berth. as the causal agent.

The disease appears to be more serious on the muck soils adjacent to Lake Okeechobee than on the sandy soils along the East Coast. Yield reductions of up to 75 percent have been noted in the former area. One 2-acre planting of the variety Florida Market (Cook's Strain) grown on land not cropped to pepper or eggplant for at least 15 years showed 80 percent infection. This and similar observations suggest that diseased seed provide the primary source of inoculum[1].

Eight varieties and hybrids were tested in the greenhouse for resistance. Plants were grown in steamed muck in 4-inch clay pots. Following emergence, a 1/4-inch square of inoculum (2-week-old culture on potato dextrose agar) was added to each pot. Results are shown in Table 1. None of the varieties tested showed any appreciable resistance.

Table 1. Relative susceptibility of eggplant varieties to Verticillium albo-atrum.

Variety	No. plants tested	Number of Plants Diseased			
		4/10/55	4/18/55	5/5/55	6/2/55
Ft. Meyer's Market	8	0	2	3	8
Florida Market (Cook's Strain)	9	0	3	4	9
Florida Market	10	0	0	3	9
Black Beauty	10	0	2	4	8
Manatee Special	9	0	3	5	9
Florida Highbush	11	3	4	7	11
Burpee Hybrid	10	0	5	5	9
Burpee Hybrid Early Prolific	9	0	1	3	9

This appears to be the first reported observation of Verticillium wilt of eggplant in Florida. The cool winter months in the southern part of the State provide weather conditions quite favorable to the development of this disease. It is not known whether the causal fungus could survive in the soil during the summer in this area.

EVERGLADES EXPERIMENT STATION, BELLE GLADE, FLORIDA

[1] Kadow, K. J. 1934. Seed transmission of Verticillium wilt of eggplants and tomatoes. Phytopathology 24: 1265-1268.

OCCURRENCE OF THE GRASS CYST NEMATODE, HETERODERA PUNCTATA, AND HETERODERA CACTI GROUP CYSTS IN NORTH DAKOTA AND MINNESOTA

By Joseph F. Spears[1]

Periodic surveys of the Nation's potato and tomato producing areas have been a part of the Golden Nematode Control Program since 1948. These surveys are advisable because early discovery of infestations of the golden nematode, Heterodera rostochiensis, Wollenweber, is of prime importance in checking its spread.

The 1955 survey conducted in the North Central States showed no infestation in Michigan, Wisconsin, Minnesota, North and South Dakota. Altogether 8,461 samples representing 85,991 acres in 88 counties were processed. In the course of processing samples for golden nematode, cysts were recovered which were identified as Heterodera punctata, Thorne (2)

(the grass cyst nematode, also referred to as the wheat nematode.)

H. punctata cysts were found in 46 North Dakota collections from Pembina, Walsh, Grand Forks, and Towner Counties. This nematode species was also present in single collections from Kittson and Clay Counties in Minnesota. Its occurrence on wheat in the Canadian Provinces of Saskatchewan and Alberta was reported in 1928. In England it is known to attack two species of bent grass, Agrostis stolonifera and A. tenuis (1).

A large number of cysts identified as Heterodera sp. (H. cacti group) were found in samples collected from Kittson, Marshall, Polk, and Clay Counties, Minnesota. A few specimens were present also in soil from Pembina County, North Dakota.

The economic importance of these nematodes cannot be determined at this time. Very little research has been done with H. punctata. The Heterodera cacti group cysts lack specific identification and its host has not been determined.

Literature Cited

1. Franklin, M. T. 1951. The cyst-forming species of Heterodera. Commonwealth Agri. Bur., England. 74-80.
2. Thorne, G. 1928. Heterodera punctata n. sp. A nematode parasitic on wheat roots from Saskatchewan. Sci. Agric. 8 (11), 707-710.

[1] In Charge, Golden Nematode Control Project, Plant Pest Control Branch, Agricultural Research Service, United States Department of Agriculture, Hicksville, New York.

POWDERY MILDEW (PODOSPHAERA TRIDACTYLA) ON ALMOND

By C. G. Weigle

Powdery mildew on almond seems to be uncommon. In September, 1954, Roderick Sprague reported having found the conidial stage of a powdery mildew on an unknown variety of almond at the Tree Fruit Experiment Station, Wenatchee, Washington. The mildew had been collected the previous June and was considered to be apparently Sphaerotheca pannosa (PDR 38: 695). He found no previous record of powdery mildew on almond in the United States.

In October, 1955, at the United States Department of Agriculture Plant Introduction Gardens, Chico, California, Archie Schlocker and H. Keith Wagnon, Associate Plant Pathologists of this Bureau, collected shoots of almond seedlings which showed mildew infection and brought them into the laboratory for identification. The seedlings were growing 1 inch apart in nursery rows and had received overhead sprinkling. Apricots, peaches, and plums growing similarly in rows between the almond rows showed no infection. According to the records of Lloyd E. Joley, horticulturalist in charge of the Introduction Gardens, 70 percent of the almond seed had come from Afghanistan and 30 percent from Pakistan and Iran, and had been purchased on the open market (bazaars) in those countries.

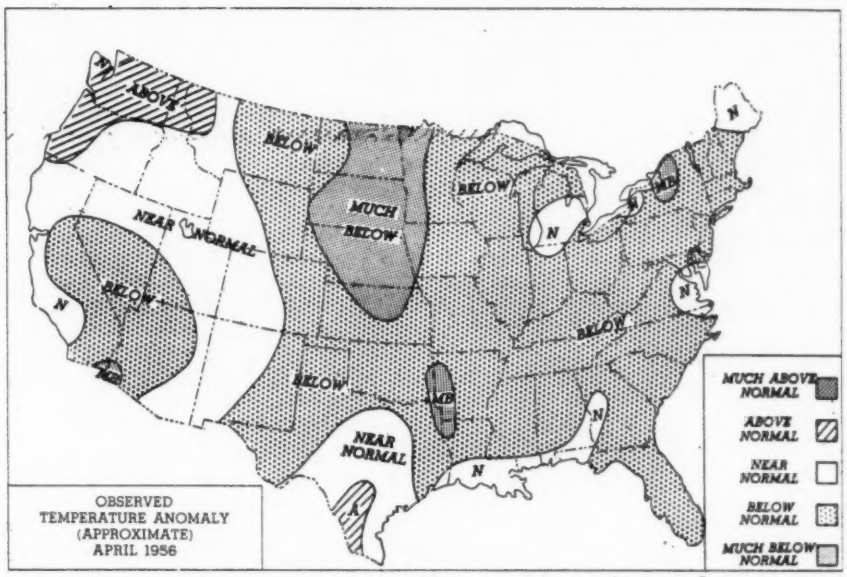
The leaves and twigs of the almonds revealed a profuse mycelial growth at first believed to be Sphaerotheca pannosa, but material from a second collection revealed perithecia of Podosphaera tridactyla. This identification was confirmed by C. E. Yarwood, University of California. We find no previous report of P. tridactyla on almond in the United States.

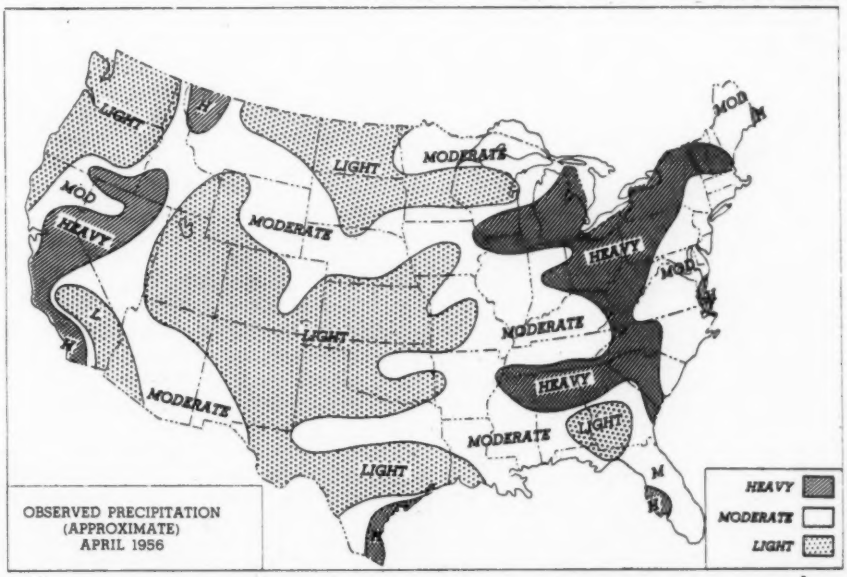
BUREAU OF PLANT PATHOLOGY, CALIFORNIA STATE DEPARTMENT OF AGRICULTURE, SACRAMENTO 14

A CORRECTION

In Supplement 237, "Host Index and Morphological Characterization of the Grass Rusts of the World" one page of the data tabulations is out of place. Page 44 belongs at the end of Group V. The following corrections should be made:

1. Annotate the bottom of page 41 as follows: "(see page 44 for the remainder of group V)."
2. Bottom of page 43 add: "Group VI continued on page 45."
3. Top of page 44 add: "Group V, continued."
4. Top of page 45 add: "Group VI, continued."





The terms used in the accompanying maps, which define the ranges of temperature and precipitation, are numerical class limits. These are based on a statistical analysis of past records through which is determined the normal frequency of occurrence of temperatures and precipitation at various times of the year for different locations. For temperature the classes above, below, and near normal are so defined that they each normally occur one-fourth of the time; much above and much below normal, one-eighth of the time Precipitation is depicted in terms of light, moderate, and heavy, each class normally occurring one-third of the time and thereby having equal probability of occurrence. These maps graphically represent only the general trends and give the country's weather picture at a glance. For quantitative studies, where monthly mean temperatures and actual precipitation records are needed for a given time and place, other publications of the Weather Bureau should be consulted. P. R. M.

MANUSCRIPTS FOR THE PLANT DISEASE REPORTER

(See also PDR 35: 121-122; 36: 214, 494)

(1) GENERAL: The Reporter page measures 9 inches long with the heading or 8 3/4 inches for the text part, by 6 inches wide. The copy is typed on a larger page, 11 1/4 inches of text or 12 inches overall in length by 8 inches in width, and reduced 25 percent in the photographic process of reproduction. Illustrations or tables larger in either dimension will take a correspondingly greater reduction. Only one size of type is available for text, footnotes, or tables.

(2) MANUSCRIPTS should be the original ribbon copy, not carbons, clearly typed and double-spaced throughout, including tables, footnotes, and bibliographies. (Note -- only one copy is needed.) Footnotes should be typed at the bottom of the page.

(3) ABSTRACTS are requested for all except very short articles. (PDR 38: 316).

(4) CAUSES OF DISEASES should be named. For bacteria, fungi, nematodes, etc., give the Latin name of the organism; for viruses either or both the accepted common name of the virus or a Latin name if you prefer it and there is one; for non-parasitic diseases state the causal factor if it is known. If the cause of a disease has not been determined say so. (PDR 36: 494).

(5) LITERATURE REFERENCES should be given in alphabetical order and numbered for citation in the text. We follow the AIBS suggestion of placing the year of publication after the author's name. Please check your titles carefully since we cannot do it for you. Be sure that text citations and bibliography agree; that foreign-language references are correct; that number or month is cited for periodicals that are not paged consecutively throughout the volume.

(6) NAMES OF FUNGICIDES should be given according to the suggestions that will be published in Phytopathology before long, and later repeated in the Reporter. In the meantime see PDR 35: 122.

(7) ILLUSTRATIONS should be sent to us unmounted. To prevent mistakes, write figure numbers on the back, and mark the top of each print when necessary. A sketch can show a preferred arrangement but please keep in mind page size, shape, and standard reduction (see above under General), and remember that figure titles and legends are part of the page. Lettering should be clear and large enough to be legible after reducing. Drawings, maps, and graphs can be photographs or originals, but should be finished and ready for reproduction, not just sketches.

(8) TABLES should be carefully thought out with particular attention to the Reporter's limitations in reproduction. Make titles and headings definite and self-explanatory. Designate footnotes in tables with superscript lower-case letters. Be sure that text discussion agrees with the data in the table. Do not abbreviate names of crop varieties.

(9) REPRINTS cannot be supplied since there is no way in which we can be reimbursed. However,

(10) The MULTILITH PLATES from which reprints can be made will be sent if requested at the time the article is submitted. The press size of these plates used for the Reporter is designated as small -- maximum image 9 1/2 by 13 inches, maximum paper size 9 3/4 by 14 inches -- for Model 1250. Most of the Experiment Stations have this type of multilith machine.

(11) We are the official correspondents in the United States of the PLANT PROTECTION BULLETIN published monthly by the United Nations Food and Agriculture Organization. We would appreciate it if plant pathologists would send us suitable material from time to time for inclusion in our monthly summary reports. Please mark it clearly so that we will know it is intended for the Bulletin. (See PDR 36: 492; 37: 637) -- P. R. M.